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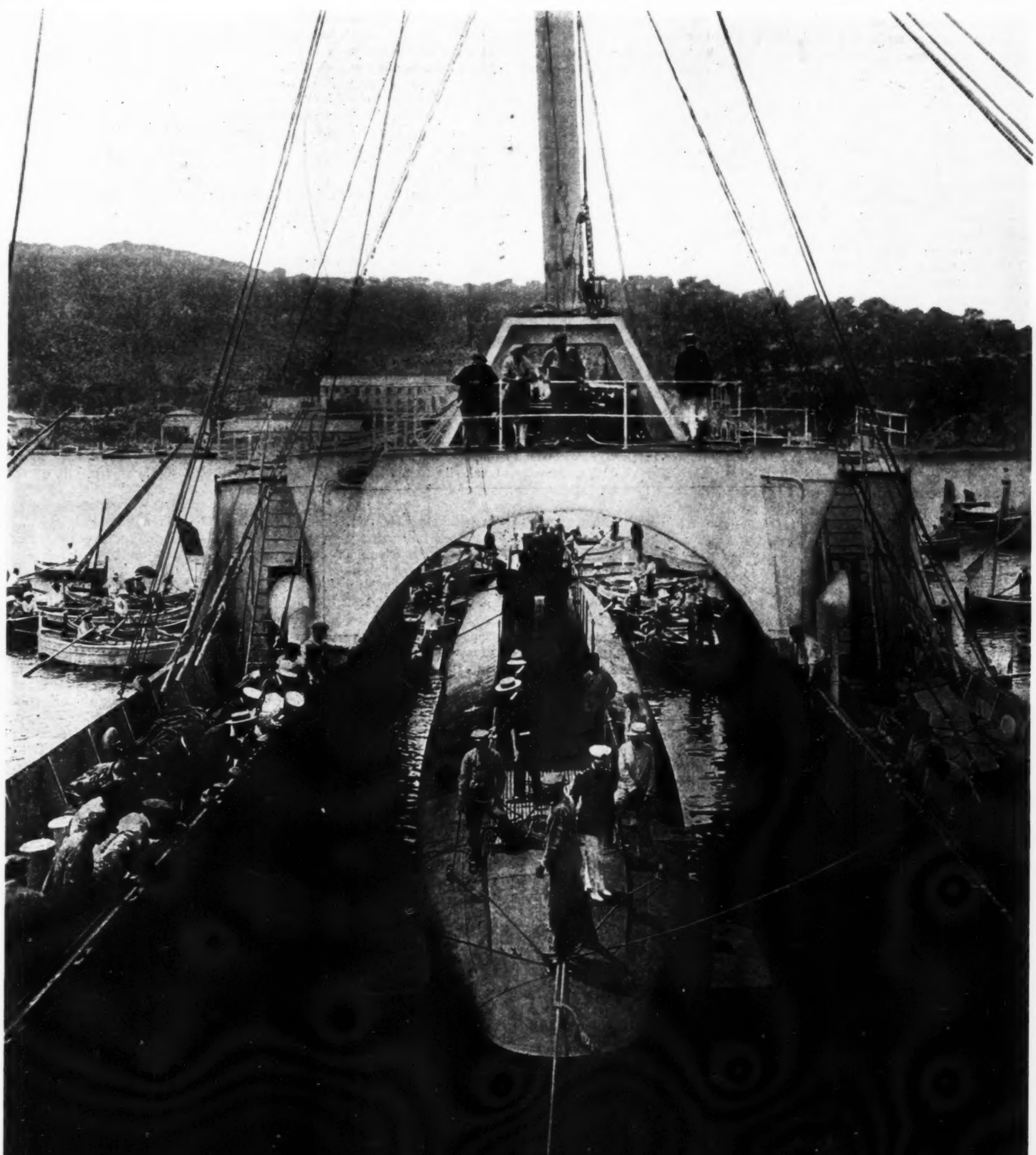


A submersible boat afloat within the ship.

THE "KANGAROO"—A SHIP FOR TRANSPORTING SUBMARINES.—[See page 356]

The Abatement of Locomotive Smoke*

Five Methods Are Available to Mitigate Existing Conditions

By D. F. Crawford

CONSIDERING the many years that the subject of smoke abatement has been under discussion, it would seem that very little has been accomplished, but this is not remarkable, nor does it apply to locomotive smoke alone or even smoke from any other source. While it may be truly said that little has as yet been accomplished in the abatement of locomotive smoke, it must be borne in mind that, taking into account the comparative difficulties of the problems presented, quite as little has been accomplished in the abatement of smoke from other sources, particularly the stationary boiler.

Of the smoke produced in any locality where bituminous or soft coal is generally used for manufacturing, power and domestic purposes, it will be found that locomotives contribute but from fifteen to twenty per cent, with perhaps a somewhat higher proportion in localities where comparatively few industries are located, and, of course, a considerably greater proportion where fuel other than bituminous coal is used for domestic purposes. The railways in America produce transportation of passengers and freight at the lowest cost of any country in the world, and to obtain this result large units and consequently large coal consumption is necessary.

The above presents the problem which confronts the railway officer in considering this subject. To obtain from the modern locomotives the average power required from them it is necessary to consume fuel at the rate of about 100 pounds of coal per square foot of grate per hour, and to obtain the maximum power required it is necessary to consume 150 pounds, and at times in excess of this amount, per square foot of grate per hour. That is, to obtain the power necessary to perform the work demanded, a boiler which from its heating surface would be rated at about 320 horse-power is frequently forced to develop over 1,500 boiler horse-power, and our records show that another boiler, which would on the basis of heating surface be rated at about 400 horse-power, has developed as high as 1,994 boiler horse-power.

The performance stated above requires coal consumption at the rate of from 6,000 to 10,000 pounds of coal per hour, and in the cases cited this was done on a grate of 55 square feet. From this it is surely evident that the abatement of the smoke from such combustion is beyond comparison with the simplicity of taking care of the smoke from a stationary boiler with the low rates of combustion obtained in such practice. Economical railway operation forbids the use of smaller units as well as underloading those in service. Therefore, the situation must be met without diminishing the efficiency of the railway as a transportation facility and with as little additional cost to the purchaser of transportation as may be possible.

Of the methods for the abatement of smoke from locomotives that are available, the following may be mentioned: 1. The use of comparatively smokeless fuels; 2. The use of air jets; 3. The use of mechanical stokers; 4. The instruction of the men operating the locomotives and supervision of their work; 5. The elimination of the steam locomotive.

THE USE OF COMPARATIVELY SMOKELESS FUELS.

Anthracite coal, low volatile bituminous coal, coke, and oil may be considered in this class, although one may be somewhat doubtful as to the inclusion of oil in this list, as the few locomotives that the writer has seen using this fuel, produced a great deal of smoke. The geological map shows conclusively that the study of the abatement of smoke must be based on the use of bituminous coals. For economic reasons as well as the proper utilization and conservation of the natural resources, the railroads must produce power with the fuel available in the territory through which they run. The available anthracite coal is located in eastern Pennsylvania, and even if the cost were not prohibitive, the entire output would not be sufficient to supply the demand for locomotives alone.

Low Volatile Bituminous Coal.—This fuel, under favorable conditions, produces considerably less smoke than that containing a large amount of volatile matter, and has been and will be used to meet special conditions. However, the supply is located at comparatively few points, and its general use would not only add greatly to the cost of transportation, but prevent the utilization of other fuels until the supply of the low volatile fuel becomes exhausted, when the problem would again come before us.

Coke.—Coke to the extent of about fifty million tons is produced per year, practically all of which is used for metallurgical purposes. Of course, the output could be increased, but can we afford the necessary loss of one third of the heat value of the coal used in its production? Coke is not a satisfactory fuel for locomotives, and its general use would considerably reduce the capacity of the existing locomotives, resulting in economic waste. The use of oil is, of course, confined to localities where it is sufficiently plentiful to warrant its use, and information is at hand that the supply is now so limited that some of the roads on which it is used are compelled to return to the use of coal.

Inasmuch as the kind of coal which will most likely be used is apparently settled by the geological distribution of the coal and the geographical location of the railways in relation thereto, it would seem necessary to devote our energies and time in an endeavor to meet the situation with the materials available. The writer will therefore take up the mechanical devices for smoke abatement with which we have had some experience.

THE USE OF AIR JETS.

It is a well-known fact that to support combustion a certain quantity of air must be supplied for each pound of fuel burned. In an endeavor to provide an adequate air supply many experiments with air or steam jets have been made, resulting in a large number of designs covering the type of jets and suggested location and arrangement. These devices for the mechanical mixture of air and gases were supposed to be equally useful for either stationary or locomotive boilers, and some of the various forms have, from time to time, been applied to quite a large number of locomotives. Notwithstanding the almost general failure of this type of smoke reducer, the occasional success was sufficient stimulus to make its use attractive to those in charge of the abatement of smoke in various localities, and to the railway officers co-operating with them in their desire to assist in smoke reduction. Therefore it was decided at a conference of railway officers to appoint a committee to make a scientific study of the scheme as well as carefully planned practical experiments. This committee, of which the writer had the honor of being chairman, was composed of representatives of seven railroads, and all of them had had long experience with the locomotive and with the use of air jets of various forms for the abatement of smoke, as well as a keen interest in the subject before them.

Upon examination of the drawings showing the arrangement, location and dimensions of jets in use on a number of railways it was found that the variations in practice were so great that without more definite information, no conclusion could be reached, and arrangements were made with the Pennsylvania Railroad for a thorough test on the locomotive testing plant installed by the company at Altoona, Pa., of a locomotive provided with jets of several designs, locations and arrangements, approved by the committee. That the testing plant is admirably adapted to "smoke observations" is evident from the fact that it may be operated continuously for a given time at a given rate with one kind of a device, or one kind of fuel, and, for comparison, be operated with another device or fuel at exactly the same rate and time as in the previous tests. With fixed conditions the results obtained with different devices or fuel may be accurately judged and rapidly determined.

To make the tests of the air jets a locomotive of the size and capacity largely used in heavy yard or switching service was equipped with all of the necessary apparatus and put on the testing plant, and a large number of tests made. Through the courtesy of the General Managers' Association of Chicago the complete report may be found in the Proceedings of the American Railway Master Mechanics' Association for 1913. Tests were first made to determine the type, location and arrangement of jets, to give the best results in reducing smoke. This information having been obtained, further tests were made to determine what effect the use of the jets would have on the efficiency of the locomotive in transportation service.

Results of Air Jet Tests.—The conclusions from the tests were as follows:

a. The steam jet combustion tube has a decided value in reducing smoke under the widely varied conditions of these tests. The results of the test indicated that when the locomotive is working so that the smoke readings would average from 25 to 30 per cent that by admission of 2,000 cubic feet of air per minute above the fire that the smoke reading would reduce to an average of about 6.5 per cent. The amount of smoke being reduced almost directly in proportion to the amount of air supplied; the practical limit being reached in this locomotive at about 2,500 cubic feet of air per minute; this amount of air causing the locomotive to fail to make sufficient steam.

b. The air injected by the tube was found to be the greatest factor in reducing smoke, although a small amount of steam seems essential in smoke reduction.

c. When using steam jets injecting air into the fire box it was apparent that a greater reduction in smoke was accomplished by their use with improper firing as compared with careful firing.

d. The fire box temperature was found to be higher when the brick arch was in service as compared with the plain fire box, although the data do not consistently show that a reduction in smoke follows increased fire box temperature.

e. The brick arch showed a considerable reduction in smoke when running, while on standing tests the brick arch showed little if any benefit in the way of smoke reduction when the proper mixture of air and steam is supplied.

f. The steam jet tubes give the best results in reducing smoke when located so that the injected air and steam meet the flame as high as possible above the fire bed.

g. Air openings in the fire door are of slight assistance in smoke abatement.

h. The best results were obtained when from 4 to 6 pounds of air per pound of coal fired was injected by the steam tubes from a location in the back boiler head above the fire door.

The tests indicated for locomotives in yard service and switching service, that for the majority of the time they are in use, the introduction of sufficient air to reduce smoke will not seriously decrease their capacity and will tend to improve the economy of coal consumption. From the above it is clear that there is a field for further study regarding the usefulness of the air jet. One of the difficulties to be overcome in the use of the air jet is the noise produced by the jets when supplying sufficient air to be of value in reducing smoke, and several forms of mufflers, or silencers, are now being used experimentally.

Since the completion of these experiments in March of this year, about thirty locomotives on the Pennsylvania Lines, and many more on the other lines used in switching service and yard service, have been equipped with the air jets; the design being modified to meet the conditions of each type of locomotive. These locomotives are under observation to ascertain whether the results obtained in actual service, where the locomotives must of necessity be handled by a large number of men, will be as favorable as those obtained under test conditions. The design of muffler is also receiving further consideration, as, without a satisfactory muffler, the noise made by the jets is sufficient to retard, if not preclude, their use.

THE MECHANICAL STOKER.

For the past nine years the Pennsylvania Lines west of Pittsburgh have been working to develop a mechanical stoker for locomotive use, and the results so far have been sufficiently satisfactory to warrant its application to a total of 300 locomotives, of which 215 are at work, 66 in passenger, 130 in freight, and 19 in switching service.

While, of course, the desire to use the mechanical stoker was primarily brought about by the desire to increase the capacity and efficiency of the locomotive, the question of smoke reduction was given full consideration, as it was felt that less smoke meant less expense of fuel. This device has proved, up to the present time, to be the most promising yet installed for the reduction of smoke from a locomotive using bituminous coal, in fact, under favorable conditions, the smoke is practically eliminated.

Repeated comparisons of the smoke produced by locomotives with and without the stoker show that those equipped with the stoker may be operated with from one tenth to one third of the smoke made by similar locomotives in the same service without the stoker; the amount of the reduction depending on the class of service and continuity of the run. Not only is the average amount of smoke made reduced, but the number of times dense smoke is produced is diminished; the large volume of dense smoke apparent

* *The Railway and Engineering Review.*

each time fuel is supplied to the fire by hand being eliminated when the stoker is used. While the apparatus is now sufficiently developed to warrant the trial of a large number, the problem of maintaining and satisfactorily operating them, with various kinds of coal, and teaching many men how to handle them to the best advantage, is still before us.

Other Devices.—It would not be proper to present a paper on this subject without mentioning two other devices, now largely used on locomotives, which assist in reducing smoke, namely, the superheater and the brick arch.

The superheater, which is now applied to many locomotives, and which will be applied to many more in the future, does much toward the abatement of locomotive smoke, in that it permits the operation at a given power output with from ten to twenty per cent less coal than a locomotive developing the same power not provided with a superheater. Less coal being required, there will consequently be less smoke.

The brick arch, by retaining heat and retarding the flow of the gases, permits their ignition, while without the arch they would escape without reaching the ignition point, and a portion at least would form smoke. The amount of smoke reduction, although comparatively small, is sufficient to warrant consideration, and application of arches alone or in combination with the other devices mentioned.

SPECIAL INSTRUCTION OF THE MEN.

Of course, in this field, as in any other, the degree of success obtained is dependent entirely on how well the work required to accomplish the desired result is done. Instruction and supervision is necessary to some extent, even when the mechanical devices named above are used. The cost of fuel represents from 8 to 10 per cent of the total operating cost of the railway and therefore one of the most obvious ways of reducing operating expenses is to economize in the use of fuel. As the methods which must be followed to obtain the maximum economy in locomotive fuel consumption are the same as those necessary to reduce smoke, the direct financial interest of the railway is the elimination of smoke. Therefore, in addition to the study and development of mechanical devices the railways, by additional supervisors and instructors, are causing reduction in the amount of smoke emitted by having more careful firing and handling of locomotives by the enginemen.

At many points the subject of smoke abatement is assigned to men whose sole duty is to observe the amount of smoke produced and instruct the engineman as to its prevention. In some localities where the locomotives of several roads operate over one anothers' tracks, the inspectors represent the several railways and report to the proper officer the emission of dense smoke from any locomotive, regardless of its ownership. Such an arrangement is particularly desirable at points where the lines of several railways are adjacent, as it permits a comparatively small number of men to observe a large number of locomotives.

ENGINEHOUSE SMOKE.

Perhaps the most difficult problem in the abatement of smoke from locomotives is the reduction of the amount of smoke made at the locomotive terminals, where fresh fires are made, to prepare the locomotives for service. Frequently at the larger terminals there will be ten or even more locomotives at one time in which the fires are in course of preparation. We all know it is quite impossible to build a fresh fire in the house grate or stove without smoke, and that quite dense smoke will continue until a considerable portion of fuel is fully ignited. The same conditions prevail with the locomotive, only greatly aggravated by the larger amount of fuel required to start the fire, and at times by the rapidity with which the work must be done to meet the demands of the service, the patrons of the railways seldom being willing to suffer delay to either themselves or their goods.

Notwithstanding careful instructions, supervision and experiments with different fuels, mixtures of fuels, and appliances, a satisfactory solution has not yet appeared. Several years ago we endeavored to collect the smoke and gases by means of suction fans and pass them through water sprays to precipitate the heavier contents, but without success; the size, first cost and cost of operation prohibiting a plant of sufficient capacity. A modification of this arrangement, in which the smoke and gases are forced through a considerable body of water, is about to be put in operation and will be watched with interest by all concerned in this subject.

At the present time the Pennsylvania Lines have under construction, at the engine house in Allegheny, apparatus to carry the smoke and gases from the locomotives in which fires are being prepared, through an underground duct and a fan, discharging them into a stack 7 feet in diameter and 150 feet high. It is felt that this arrangement will not only carry the smoke and gases considerably above the buildings immediately adjacent to the engine house, but, owing to the size of the stack, permit of considerable precipitation of the heavier particles. The stack will be so located that it will be possible to interpose smoke washing apparatus between it and the fan, should a sufficiently promising method be developed. Mention is made of this only as information to the effect that all phases of the subject are receiving careful attention of the railway officials, and that the railways are making expenditures of considerable magnitude in their endeavors to abate smoke.

ELIMINATION OF THE STEAM LOCOMOTIVE.

In the present state of the art, of course, this means the substitution of electric motive power for all the locomotives now in use, as no other method is now available. The word "Electrification" seems to be attractive to everyone, save those charged with the responsibility of obtaining the money required to meet the enormous outlay of capital required to install the apparatus and then to continue the operation at rates for carrying passengers and freight which will be deemed reasonable by the patrons, as it has not been demonstrated that electrification will generally result in reduced operating costs.

From the best data available the complete electrification of the railways would eliminate only some 20 per cent of the smoke annoyance, and the writer has often wondered why its application, to ameliorate the discomforts caused by the remaining 80 per cent, has not been more strongly urged. Undoubtedly electric power may be substituted for steam power for many purposes for much less capital outlay, with more promise of a satisfactory return on the investment and with less probability of unsatisfactory service to patrons, than is the case with its use by the railways.

From the information offered by many writers on the subject, one would be led to believe that a steam locomotive is a most wasteful machine and that tremendous savings would result from abandoning their use. As a matter of fact, the performance of the locomotive boiler compares favorably with the average results obtained in stationary practice, and the performance of the complete locomotive, of modern construction, is sufficiently efficient to permit of obtaining a coal rate of 2.1 pounds per indicator horse-power hour, or 2.5 pounds of coal per horse-power hour delivered at the drawbar of the tender. Surely such results do not warrant the almost general belief that the locomotive is an inefficient machine for the purpose for which it is intended.

Without doubt the use of electric motive power in lieu of the steam locomotive will be extended, but its use will, at least until there is great improvement in the efficiency, reliability and reduction of the cost of electrical apparatus and its operation, be confined to meeting special conditions, such as the operation of the lines through tunnels, similar to those under the rivers at New York and Detroit, those in long tunnels through mountains, and certain lines with exceedingly heavy grades and a large volume of traffic, as well as some terminal passenger stations where the location and traffic conditions are such as to readily permit of its adoption.

THE COST.

The cost of everything electric is enormous. The cost of the electric locomotive is at least double that of the steam locomotive, which they are supposed to replace, and before electric locomotives can be operated it is necessary to incur a large additional outlay for power houses, transmission systems, track preparation and all of the other apparatus and material which is necessary to complete an electric system. One estimate which has been brought to the writer's attention provides an investment of about $200,000 for each steam locomotive displaced, or about ten times the cost of each of the latter. As there are about 70,000 locomotives in the United States, representing an investment of about one billion four hundred million dollars, you will surely agree that some exceptionally favorable return must be apparent before they will all be discarded; especially so when their replacement involves an expenditure of many times their present value.

It is true that the demand is rarely made that an entire cross country line be operated by electric power, but that such operations be confined to the larger cities. Such an installation, however, except under particularly favorable conditions, involves not only a proportionately heavier investment for the electric plant, but requires the establishment of two locomotive terminals, one each side of the city, and an additional stop at each of the termini for an exchange of the steam for an electric locomotive or *vice versa*. Even if the railways could stand the burden of the cost, it is doubtful if the traveling public would tolerate frequent delays of this kind.

While, of course, with an unlimited expenditure of money much might be accomplished by electrification of the railways, to reduce the proportion of smoke now produced by them, it would seem wise to first provide for the transportation and terminal facilities required to meet the growing needs of our country's commerce, and the elimination of grade crossings, etc., before devoting any considerable sum to eliminating a comparatively small amount of the smoke in a particular community.

Orchids and the Evolution of the Species

For the last fifteen years a learned Frenchman, M. Noel Bernard, has been constantly studying the problem of the evolution of species that was, at one time, considered by many as inaccessible to laboratory methods, and reserved merely for the speculations of philosophers. By applying the Pasteurism methods to the study of the parasites of plants, M. Noel Bernard has, by decisive experiments, shown the preponderating rôle that have in all probability been played by microbian maladies in past millenniums in the evolution of vegetable species. This botanist has shown how one of the strangest flowers of our gardens, the orchid, cannot propagate unless the tiny seeds that fill the cavity of its fruit with an impalpable dust are attached by parasitical fungi. The rudimentary seeds of the orchid are incapable of developing in the same conditions which suffice for the germination of other grains. M. Noel Bernard has reproduced in his laboratory diverse orchids. He has observed that living together with the fungi is imposed as a necessity to these perversely colored flowers. Like Pasteur, Chamberland, and Roux, who showed that the virulence of bacteria can be increased, M. Noel Barnard has discovered a striking analogy of these phenomena in the case of orchids. By appropriate cultures the learned botanist has obtained far more active fungi than those that are normally met with, and capable of germinating a greater number of seeds of one seeding. From a general inquiry made concerning the parasitism of the higher grades of plants, MM. Noel Bernard, J. Magrose, and C. Bean have arrived at the conclusion that it is highly probable some state of vegetables must be considered as being, to a certain extent, the symptom of an infectious disease. Prof. Gaston Bonnier, in a notice that he read before the Academy in the name of M. C. Bean, has confirmed these researches. An orchid of our countries, the autumn spiranthis, has been the object of his studies. The germination of this orchid likewise cannot take place unless associated with a special filamentous fungi—the orchid gets rid of its associate to live separately. These experiments, which may find practical important application for the culture of all kinds of orchids, are susceptible one day of making biologists masters of the evolution of vegetable species.—*Chemical News.*

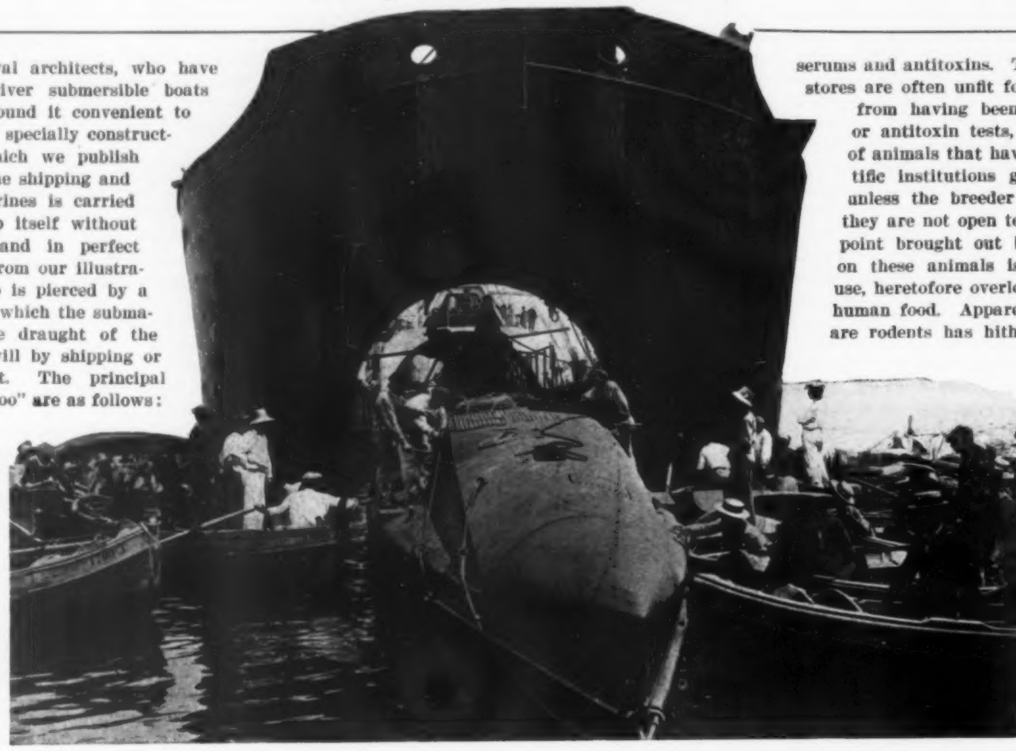
Engine Starters for Aeroplanes

The starting of aeroplane engines otherwise than by swinging the propeller by hand, which was indicated as one of the desiderata for the military aeroplane competition of 1912, seems to have made much less headway than might have been expected, considering the urgency of the need for such a device. Perchance out of the goodly list of entrants in the forthcoming aeroplane engine competition (April, 1914) something quite new may appear. At present the motor-car engine starters are not of much help. The great run on electric starters is deflecting attention from devices which might require less weight. A battery capable of giving from 50 to 60 amperes at 12 volts, a motor which will not burn out under this load, a gear reduction (even be it but pulleys and belts) which will allow so small an electric input to turn a 70 or 100 horse-power engine fast enough to draw in the proper mixture to compress it, will require at the best an added weight of over 100 pounds. This figure is a strong deterrent. At the 1912 M.A. Trials the dual ignition (magneto and trembler coil) gave what results were then thought passable. The compressed air cylinder with distribution pipes and valves to the cylinders was known and tried, but it was rather heavy. A lighter plan, that of designing the engine with a camshaft such that the exhaust valves could be lifted and mixture pumped in by hand, to be eventually fired from a trembler coil, was in use abroad some years ago, but has not yet obtained any vogue. Acetylene starters also lag behind in aeronautics. The imperative and unavoidable necessity for starters for seaplanes will automatically push the subject into prominence, and it certainly will repay further study.

The "Kangaroo"

Transport Ship for Submarines

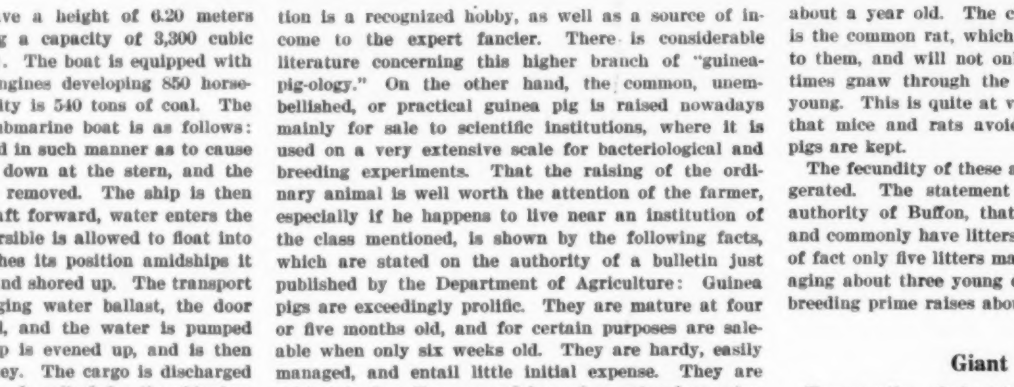
A French firm of naval architects, who have frequent occasion to deliver submersible boats to foreign navies, have found it convenient to provide themselves with a specially constructed transport boat, of which we publish illustrations herewith. The shipping and unshipping of the submarines is carried out by the transport ship itself without any outside assistance, and in perfect safety. As will be seen from our illustrations the hull of the ship is pierced by a broad central tunnel, into which the submarine can be drawn. The draught of the vessel can be varied at will by shipping or unshipping water ballast. The principal dimensions of the "Kangaroo" are as follows: Length between perpendiculars, 305 feet; extreme breadth, 39 feet 4 inches; depth, 23 feet 10 inches; mean draught, loaded, 19 feet 7 inches; displacement at the said draught, 5,540 tons; dead-weight carrying capacity, 3,830 tons; speed, 11 knots. The hold measures 59 meters (193 feet 6 inches) in length, 9 meters (29 feet 6 inches in breadth, and the vertical sides have a height of 6.20 meters (20 feet 4 inches), giving a capacity of 3,300 cubic meters (116,545 cubic feet). The boat is equipped with vertical triple-expansion engines developing 850 horsepower. The bunker capacity is 540 tons of coal. The operation of shipping a submarine boat is as follows:



Submarine being warped, stern first, through the open bow of the "Kangaroo," into the hole.

Water ballast is admitted in such manner as to cause the transport ship to dip down at the stern, and the door closing the tunnel is removed. The ship is then allowed to increase her draft forward, water enters the inner dock, and the submersible is allowed to float into the tunnel. When it reaches its position amidships it is placed over keel blocks and shored up. The transport is then raised by discharging water ballast, the door to the tunnel being closed, and the water is pumped out of the dock. The ship is evened up, and is then ready to start on its journey. The cargo is discharged by reversing the operations described for the shipping.

The crew consists of the captain, chief officer, three engineers, two petty officers, thirteen seamen, including stokers and two boys, a total of twenty-two hands. Accommodation is provided for these and also for two officers, four petty officers, and sixteen men, forming the officers and crew of a submersible boat.



The "Kangaroo" with stern open to receive a submarine.

The "Kangaroo" has been designed primarily for the transport of submarines as stated. But it can do duty also for carrying heavy and bulky loads, such as turbines, locomotives, etc., which can be lowered into the hold amidships. The "Kangaroo" has now been in service for some time and has proved itself well adapted to its task.

Practical Guinea Pigs

The raising of guinea pigs is one of those minor rural industries that never enter into the calculations of the average farmer, but that might, if he would give them a little attention, prove both interesting and lucrative variations from the routine work of the farm.

Guinea pigs may be divided into two classes—the fancy, and the practical. Fancy guinea pigs are raised for pets and for exhibition purposes, and have given rise to many curious varieties, so that their cultivation is a recognized hobby, as well as a source of income to the expert fancier. There is considerable literature concerning this higher branch of "guinea-pig-ology." On the other hand, the common, unembellished, or practical guinea pig is raised nowadays mainly for sale to scientific institutions, where it is used on a very extensive scale for bacteriological and breeding experiments. That the raising of the ordinary animal is well worth the attention of the farmer, especially if he happens to live near an institution of the class mentioned, is shown by the following facts, which are stated on the authority of a bulletin just published by the Department of Agriculture: Guinea pigs are exceedingly prolific. They are mature at four or five months old, and for certain purposes are saleable when only six weeks old. They are hardy, easily managed, and entail little initial expense. They are subject to few diseases and have few natural enemies. They require about the same diet as rabbits. The supply is not equal to the demand; formerly the average price was about 75 cents, but the laboratories are now paying from $1 to $1.50; and even at this price have in many cases been obliged to start their own breeding establishments, because it is impossible otherwise to obtain as many as are required. The United States Bureau of Animal Industry has two such establishments near Washington.

The guinea pig is the domesticated variety of the cavy. It is not a pig, but a rodent, and it does not come from Guinea, but from South America.

For four centuries the guinea pig was regarded merely as a pet and bred for show and fancy alone. Nowadays it is in great demand for experimental uses in the preparation, testing, and standardizing of serums and antitoxins. The guinea pigs found in bird stores are often unfit for laboratory purposes, either from having been previously used for serum or antitoxin tests, or from being the offspring of animals that have survived such tests. Scientific institutions generally will not buy them unless the breeder can furnish assurance that they are not open to these objections. The novel point brought out by the department's bulletin on these animals is that they have one other use, heretofore overlooked—they are available for human food. Apparently the mere fact that they are rodents has hitherto prevented their general use for this purpose. They are nearly related to rabbits and are wholly vegetarian in their habits. All the wild species are accounted good game in their original home. They may be roasted, baked whole, or cut into small pieces and fried or fricasseed. The males become somewhat strong-flavored with age, but are said to be fine when four to five months old, while females are probably at their best when about a year old. The chief enemy of the guinea pig is the common rat, which is attracted by the grain fed to them, and will not only steal their food, but sometimes gnaw through the hutch walls and devour the young. This is quite at variance with the popular idea that mice and rats avoid the premises where guinea pigs are kept.

The fecundity of these animals has been greatly exaggerated. The statement is commonly made, on the authority of Buffon, that they breed every six weeks and commonly have litters of twelve each. As a matter of fact only five litters may be expected in a year, averaging about three young each; so that a female in her breeding prime raises about twelve to fifteen each year.

Giant Tadpoles

The question of giant tadpoles of the common frog is studied by Dr. Hahn, a German scientist. In raising tadpoles, there is sometimes seen a specimen of much greater size than the others, and instead of going through the usual development it keeps the primitive state for a long time, all the while increasing in size. He observed four specimens of this kind, and they were as much as 5 inches long, while the normal tadpoles of the same stage were only an inch or over. On dissecting, he finds that the intestines, liver, pancreas and the like have the usual size, but on the contrary the ovaries—and all such specimens are females—are of enormous size and extend all along the inside of the body, while in the ordinary specimens they are scarcely visible. Such ovaries are, moreover, found to be fully mature. Study of the different organs shows many interesting details such as an advanced formation of bone, while there is only cartilage seen in the other specimens. In general it is noticed that there is a return as it were to ancestral forms which belong to fish or the like.

Wood block paving, tried and discarded in many cities of the United States thirty years ago, is now coming back into marked favor, owing to improved methods of treating and handling the blocks.

New Units in Aerology

By Alexander McAdie

In the *Monthly Weather Review* for August, 1908, the writer described a method of presenting pressure variations in percentages or permillages of a standard atmosphere. The paper was extensively commented upon and a particularly valuable review printed in a later issue, March, 1909, by Dr. W. Köppen of the *Deutsche Seewarte*, Hamburg, who pointed out that if pressures were measured in bars or millibars, as employed by Bjerknes and Sandstrom in 1906 and proposed by others before and after that date, then all the advantages of the percentage system advocated by me would be realized, with the additional gain that all pressures would then be expressed in dynamic units in the C. G. S. system, that is, 1 millibar = 1 dyne. This result is attained by making 750.1 millimeters the base pressure instead of 760.0 millimeters. The new base is the pressure at a height of 106 meters (348 feet), above sea level. In other words, instead of using the pressure indicated by 760 millimeters (29.92 inches), which in force units would be 1,013,303 dynes, obtained by multiplying 1,033.291 grammes per square centimeter by the normal acceleration of gravity, 980.65, we use the force corresponding to a pressure reading of 750.1 millimeters (29.532 inches). Dr. Köppen also presented to the Aerological Congress at Monaco, April, 1909, a strong plea for the use of dynes. At the close of this paper is given a short bibliography of the various proposals to use C. G. S. units in measuring atmospheric pressure. The International Commission for the scientific investigation of the upper air, meeting at Vienna in 1912, adopted the following resolutions proposed by Bjerknes:

"Pressure shall be expressed in bars or in decimal parts thereof, decibars, centibars, or millibars, instead of millimeters of mercury. This resolution will become operative only when the International Meteorological Committee has assented to it.

"Dynamic heights in dynamic meters shall be given instead of geometric heights 'in ordinary meters.'

"Heights at which the following pressures are found shall be given:

1000 millibars (=750 mm. Hg.).(=29.531 mercury inches)
900 millibars (=675 mm. Hg.).(=26.578 mercury inches)
800 millibars (=600 mm. Hg.).(=23.625 mercury inches)
700 millibars (=525 mm. Hg.).(=20.672 mercury inches)
600 millibars (=450 mm. Hg.).(=17.719 mercury inches)
500 millibars (=375 mm. Hg.).(=14.766 mercury inches)
400 millibars (=300 mm. Hg.).(=11.812 mercury inches)
300 millibars (=225 mm. Hg.).(= 8.859 mercury inches)
200 millibars (=150 mm. Hg.).(= 5.906 mercury inches)
100 millibars (= 75 mm. Hg.).(= 2.953 mercury inches)

In the quarterly *Journal* of the Royal Meteorological Society for April, 1913, and in various meteorological publications of continental Europe, especially the *Meteorologische Zeitschrift*, Bjerknes, Köppen, Trabert, Gold and others have discussed the proposal to publish pressure values in absolute units and also the use of the dynamic meter. While Trabert and some physicists object, the general opinion appears to be that for scientific purposes at least these units for pressure should be used without further delay.

It seems to the writer that we should also as soon as possible publish temperatures as measured from the absolute zero on the Centigrade scale and furthermore as speedily as possible use definite units for wind velocity in meters per second, wind direction in degrees and precipitation in millimeters. In the *American Journal of Science*, October, 1910, the writer has discussed these various new units and given values for such of the constants as are most frequently employed in aerological work.

The object of the present paper however is to call attention to a convenient method of converting pressure readings, as given on an ordinary aneroid barometer, into dynes. We also show how the record of an ordinary barograph can be readily converted into dynes. Fig. 1 shows an ordinary wall aneroid such as can be purchased for about $10. A graduated sheet is pasted over that portion of the glass case generally emblazoned with "Fair," "Dry," "Wet," "Very Wet," "Stormy," which in itself is a decided gain as it eliminates these misleading legends. The figure 100 on the new scale is brought in line with the reading 29.53. This represents the pressure of 1 megadyne. Every whole number represents 10,000 dynes and every tenth 1,000 dynes. One can therefore read off the equivalent in dynes for any given pressure in inches or millimeters. Also since the dynes are decimals one may read off directly the variations in pressure in percentages of a standard atmosphere. Thus, if the reading of the innermost dial were 3, this would mean that the pressure was 3 per cent above a standard pressure, whereas if the reading were 98, one would know that the pressure was 2 per cent below a standard pressure. The total variation of the two readings would be 5 per cent and the meaning of this, that there had been a variation of pressure, measured in units of force, of 50,000 dynes.

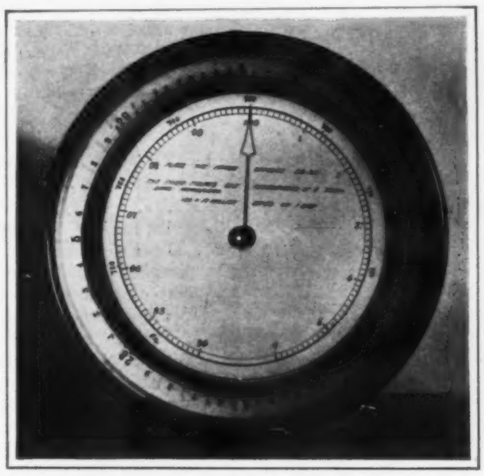


Fig. 1.—Barometer showing pressure in dynes.

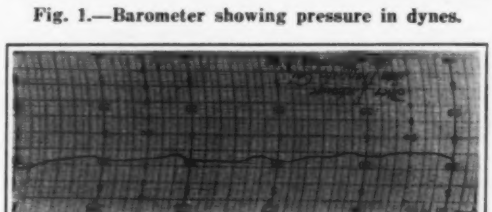


Fig. 2.—Barograph record showing variation of pressure in percentage of standard pressure of one million dynes.

In Fig. 2 the ordinary barograph sheet has had printed over the usual scale divisions a series of black lines so arranged that one can read the pressure in inches or dynes.

Both methods have been in use at San Francisco since 1910 in the Weather Bureau office and on the floor of the Chamber of Commerce and no difficulties have been experienced. The new method greatly simplifies compilation at the end of the month.

HISTORY OF MOVEMENT.

B. A. A. S., 1888 meeting, page 28. A committee of the British Association proposed the use of the Barad, pressure of one megadyne per square centimeter.

Monthly Weather Review, vol. xxvi, 1898, page 314, Cleveland Abbe discusses measurement of pressure in standard units of force.

C. E. Guillaume proposed to International Congress of Physicists in 1900, use of megadyne under the name Barye; and this was favorably reported by a committee of the Congress. (Travaux Congr. Int. Phys., Paris, 1900, t. iv., pp. 61 and 62.)

Sandstrom and Helland-Hansen in their report on "Marine Investigation," dated 1902, used the megadyne and the unit of atmospheric pressure and also for hydrostatic pressure.

Bjerknes and Sandstrom, in 1906, used the unit *bar* as mentioned by Köppen, Quarterly *Journal* Royal Met. Soc., April, 1909.

Monthly Weather Review, August, 1908, New Units.

Monthly Weather Review, March, 1909.

New Units in Aero-physics, McAdie, *American Journal of Science*, vol. xxx, October, 1910.

During 1910 Köppen, Shaw, Gold, Harwood, Dines, McAdie and others have used the bar in discussing aerological data.

Shaw, in his "Forecasting Weather," 1911, has a chapter on the C. G. S. system of meteorological units.

The Carnegie Institution has published two volumes by Bjerknes on "Dynamic Meteorology and Hydrography," 1910, 1911.

The Frick Electric Steel Induction Furnace*

Results Achieved at the Krupp Plant at Essen

An important paper of great length on "The Electric Refining of Steel in an Induction Furnace of Special Type" was read by Otto Frick, London, before the Brussels meeting of the Iron and Steel Institute. The author devotes much space to the future development of the electric furnace, not so much from a general point of view as from that of the use of the Frick induction furnace, his own invention. The conclusions presented are based entirely on results obtained in the Frick furnaces at the Krupp works in Essen, Germany. Mr. Frick believes "the time will come when half the steel produced will have been passed through the electric furnace." The salient points in the paper are abstracted as follows:

THE INSTALLATION AT KRUPP'S.

Two furnaces of the Frick type are at work in Essen. The first furnace came into regular operation in August, 1908. The second furnace, originally of the Kjellin type, was rebuilt on the same principle as the first Frick furnace. The data relating to these furnaces are:

Raw materials	cold scrap of good analysis
Capacity	10 tons
Kilowatts for which furnace designed	736
Actual working capacity	8.5 tons
Weight of casts	6.5 tons
Average power used	650 kilowatts
Frequency	5 cycles per second
Voltage	5,000
Power factor, cosine ϕ at 8.5 tons	0.35
Average duration of one heat	6 hours 45 minutes
Theoretical power consumption per ton, 432 kilowatt-hours calculated.	
Average electrical loss	4.5 per cent
Average radiation loss	160 kilowatts
Average total efficiency	70 per cent

Figs. 1, 2 and 3 give a clear idea of the design of the 10-ton 1,000 horse-power, Frick furnace at Essen, Fig. 1 showing the longitudinal section, Fig. 2 the transverse section, and Fig. 3 the plan.

The furnaces are used for the melting of cold scrap into various products. Table 1 gives the analysis and the mechanical properties of a number of steels made in these furnaces. In designing the furnace an attempt was made to fulfill the following conditions:

CONDITIONS TO BE MET.

Rotating Cover.—As the furnace was to be used for melting cold scrap only without any refining, the original type with a rotating cover was chosen, specially designed for the treatment of cold scrap and offering the advantage of easy charging and distribution over the whole crucible without any delay or trouble. The rotating cover further facilitates the supervision of the metal and of the furnace walls. Additions of slag or alloys are quickly and evenly distributed over the bath. The design of the cover has proved most satisfactory for its purpose.

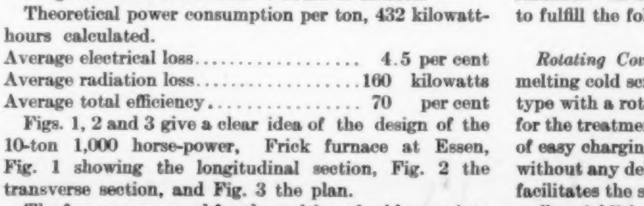


Fig. 1.—Longitudinal section.

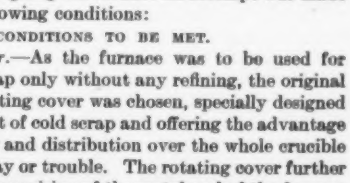


Fig. 2.—Transverse section.

Ten-ton Frick furnace, 1,000 horse-power, at the Krupp Works, Essen, Germany.

* Reproduced from *The Iron Age*

Table 1.—Electric Steel Made in the Frick Furnace at the Krupp Works in Essen

	C.	Si.	Mn.	P.	S.	Cu.	Elastic limit, kg.	Tensile strength, kg.	Elongation, per cent.	Contraction, per cent.
Screw shaft	0.38	0.23	0.30	0.020	0.024	0.06	....	50.4	27.5	65.0
Rod	0.39	0.16	0.58	0.024	0.027	0.05	37.1	59.2	23.2	64.0
Press screw	0.43	0.20	0.30	0.027	0.025	0.08	30.1	54.8	28.3	61.0
Tender shaft	0.47	0.12	0.51	0.023	0.020	0.06	....	58.1	30.5	61.0
Screw shaft	0.47	0.23	0.37	0.023	0.025	0.09	30.9	54.8	26.5	64.0
Rod	0.51	0.10	0.54	0.032	0.033	0.06	38.9	65.4	21.7	57.0
Piston-rod	0.55	0.10	0.43	0.026	0.025	0.07	....	70.7	18.3	54.0
Shaft	0.62	0.10	0.32	0.023	0.023	0.07	42.4	68.1	21.2	58.0
Rod	0.61	0.04	0.45	0.020	0.024	0.04	40.7	71.6	17.5	50.0
Tires	0.72	0.16	0.37	0.025	0.023	0.06	44.9	77.4	18.0	51.7
Tires	0.77	0.15	0.40	0.013	0.015	0.06	49.3	83.7	16.6	46.0

Losses and Efficiency.—The most essential points with regard to the design of electric furnaces are the efficiency and power consumption. The efficiency is dependent alone on the care with which the losses, consisting of electric losses and radiation losses, are kept down.

The electric losses, that is, the losses in the primary coils and in the magnetic iron core, are reduced by giving these parts ample dimensions. Notwithstanding the great weight of the core, nearly 45 tons, the total electric loss in the furnace in Essen only amounts to 4.5 per cent of the total energy supplied to the furnace. Of greater influence on the efficiency are the losses due to radiation. The author has made a careful study of the heat conductivity of refractory materials at highest temperatures, and has provided his furnaces with insulated walls in accordance with the results.

Further, great care was taken to make the doors in the cover tight and as easy as possible to keep closed. By these means the radiation losses were reduced to a minimum. Comparative calculations have shown that the radiation loss of the Kjellin furnace exceeds that of the Frick furnace by 75 kilowatts or 48 per cent, which also involves an increased cost for current, labor, and lining in the case of the former.

As an example, a run of six weeks' duration may serve. The calculated costs are not based on any actual figures from the Krupp plant, as no such are available, but for the comparison the estimated figures will be close enough:

	Type of furnace		
	Kjellin		Frick
Output in six weeks, good ingots, tons.	696		850
		Shillings	
563,500 kilowatt-hours at 0.43 penny.		20,250	
Labor estimated at		5,900	
Lining		2,000	
Light, cooling fan, etc		450	
Total costs in six weeks		28,600	
Costs per ton of ingot	41.10		33.70
Saving by Frick furnace, per ton		7.40	
Saving by Frick furnace, per campaign		6,300	
Saving by Frick furnace, in one year of seven campaigns with one furnace		44,000	

Were 12 per cent interest and depreciation on an estimated outlay of 12,500 pounds also taken into account, the annual saving would be increased to 2,500 pounds. These figures demonstrate the importance of low radiation losses, and prove the effectiveness of the design of the Frick furnace in this respect. Nearly six years of actual working have shown that no drawbacks have been caused by the insulation of the furnace.

COMPARISON WITH GIROD FURNACE.

At the Krupp works a Girod furnace of 1,200 kilowatts and 12 tons capacity has been installed next to the Frick furnace, thus giving an opportunity to compare the Frick furnace with a furnace of the arc type.

No accurate figures for the power consumption of the Girod furnace have been furnished by Messrs. Krupp, as in the case of the Frick and Kjellin furnaces, but for comparison the following figures represent average results, and will give a fair idea of the relative efficiency of the two types.

Kilowatt-hours per ton of steel in the Girod furnace. 1,000
Kilowatt-hours per ton of steel in the Frick furnace. 600

It may be assumed that the theoretical energy consumption of the Frick furnace is 425 kilowatt-hours per ton. For the Girod furnace it has been assumed to be somewhat higher, or 460 kilowatt-hours per ton, as it is possible that this furnace is working on a raw material with more scale or rust, and therefore under less favorable conditions.

It has been assumed that the Frick furnace has an interval of only 7½ minutes between heats. For the Girod furnace two cases have been calculated, viz., for an interval of 55 minutes and for one of 1 hour 25 minutes per heat, the longer intervals being necessary for charging, which has to be completed before the current can be turned on, whereas in the Frick furnace the current may be put on immediately after tapping. These calculations show:

The average loss of the Frick furnace is. . 186 kilowatts
The average loss of the Girod furnace is 567
to 594 kilowatts, or about. . . . . 580 kilowatts

Over three times more than the Frick furnace, although the capacity of this latter is only 20 per cent less.

The superiority of the Frick furnace over the arc furnace does not only depend on the better heat insulation of the former furnace, but is also founded upon the great difference between the methods of heating. In the Frick furnace the heat is generated directly in the steel bath, and consequently there is practically no heat transfer necessary, but the highest temperature prevails in the metal itself. Further, the slag acts as a very effective heat insulator, which prevents the furnace walls above the bath and the roof from becoming as hot as the bath itself.

In an arc furnace the essential part of the heat is generated in the arc or arcs playing between the ends of the electrodes and the metal, and consequently the heat has to be transferred from these centers to the other parts of the bath by heat transmission, which requires a very high temperature in the arcs and at the lower end of the electrodes, a temperature which certainly exceeds 2,500 deg. Cent., whereas the highest temperature in a Frick furnace never exceeds 1,680 deg. Cent. at any part. The heat generated in the arc is spread in all directions, and according to the existing laws of nature the greater part of the heat will go in the direction of the least resistance.

It must also not be forgotten that the electrodes themselves are fairly good heat conductors, and through them no small amount of heat is conveyed away out of the furnace. In melting cold scrap the conditions are somewhat more favorable, as the electrodes are surrounded by the charge, which absorbs some of the heat otherwise dissipated toward the roof.

It may therefore be concluded that the efficiency of an arc furnace for treating liquid metal will always be less than 50 per cent and in melting cold scrap will only slightly exceed 50 per cent. The Frick furnace, on the other hand, shows an efficiency over 70 per cent, which may be further improved with larger furnaces.

[At this point Mr. Frick discusses various difficulties offered by certain furnace linings and the effect of the inclination and rotation of the bath, its advantages and disadvantages.]

CONCLUSIONS FROM RESULTS AT ESSEN.

The results of the Frick furnaces at Essen, compared with those of furnaces of other types, may thus be summarized:

1. The design with a rotating cover has been found most suitable for melting cold stock.
2. The efficiency of the Frick furnace is much higher than that of other induction furnaces and of arc furnaces. Consequently the energy consumption per ton of steel is lower, the annual production is higher, and the cost of production is materially lower than in other furnaces.
3. The method of making the lining and of preventing the cutting by the slag has lengthened the life of the lining up to three months without repair, a result which has not been improved upon by any other furnace.
4. The inclination and rotation of the bath are sufficient to secure all possible advantages and are at the same time small enough to obviate the necessity of having too much slag to cover the bath. In this respect the Frick furnace is decidedly superior to other induction furnaces, and cannot be surpassed by arc furnaces.

It may be said that the future of the electric furnace for steel production will be in the final refining of steel, pre-melted and pre-refined either in a converter or open-hearth furnace, and that its use for melting cold stock, except in places with very cheap water power and high price of fuel, will be restricted to comparatively small quantities of high-class alloy steel, and to the melting of valuable alloys for the addition to ordinary steel, if a saving of alloy can be effected by melting under exclusion of air, as for instance in the melting of ferromanganese.

REACTIONS IN THE INDUCTION FURNACE.

Among metallurgists the conviction is general that the induction furnaces are not and cannot be suitable for refining. This view is based upon the opinion that the first and most important condition for successfully carrying out refining reactions is that the slag should be thin and liquid. As, however, the slag in the induction furnace is colder than the bath, it is impossible for it to be both thin and basic enough. This opinion about the importance of a thin slag has its origin from the experience with open-hearth furnaces.

In the case of the open-hearth furnace it is certainly correct, that a practical refining is not possible without a thin slag. The author is, however, of the opinion, that the thinness of the slag is in this case only of importance for the heat transmission from the hot gases to the bath. Owing to the fact that in an induction furnace the heat is generated in the steel itself, the temperature at the contact between steel and slag becomes independent of the thinness of the slag, which may be given such a composition as will best insure the reactions aimed at. Dephosphorization can only take place if the phosphorus in the steel has an opportunity to combine with oxygen in the presence of a slag rich in basic substances, preferably lime, and the reaction will take place so much quicker the richer in lime, and consequently the thicker, the slag is. The richer the slag is in lime, and the thicker it is, the greater is its avidity to thin and to become more easily fusible by the absorption of acids; and as it is necessary for a good dephosphorization that most of the silicon should have been previously eliminated, the only remaining acid to satisfy the slag is the phosphoric acid, which under these conditions is most readily formed.

As to the desulphurization, the idea of the importance of a thin liquid slag has apparently been strengthened by the experience with the open-hearth furnace, where it has been found next to impossible to eliminate the sulphur down to any low value. The oxidizing atmosphere of the open-hearth furnaces, and the impossibility of ridding the slag of the oxides of iron and manganese, are the true causes why no desulphurization is possible in the open hearth furnace.

Concerning the arc furnace it has been stated that desulphurization is only possible after the temperature has been raised so high as to enable the formation of calcium carbide. The publications of the Héroult furnace in this direction have undoubtedly had an influence in spreading the theory of the importance of a thin slag for the desulphurization. In an arc furnace it may be of more importance to have a thin slag, as in this type of furnace the heat has to be transmitted through the slag to the metal, but in the induction furnace it is only necessary to have regard to the best slag composition for the elimination of sulphur. Altogether excellent results with regard to desulphurization have been obtained in induction furnaces, among which those in Dommeldingen might be mentioned, where, according to analyses published in *Stahl and Eisen* of 1911, steel of 0.012 per cent sulphur to traces, with an average of 0.008 per cent sulphur, has been produced out of a raw material containing about 0.04 per cent sulphur.

In the electric furnace the following reactions take place respectively, and may be carried out:

1. Decarburization.
2. Desiliconizing.
3. Dephosphorization.
4. Deoxidation.
5. Rephosphorization.
6. Desulphurization.
7. Recarburizing.
8. Alloying with silicon, manganese, nickel, chromium, tungsten, etc.

[Mr. Frick enters into an exhaustive discussion of each

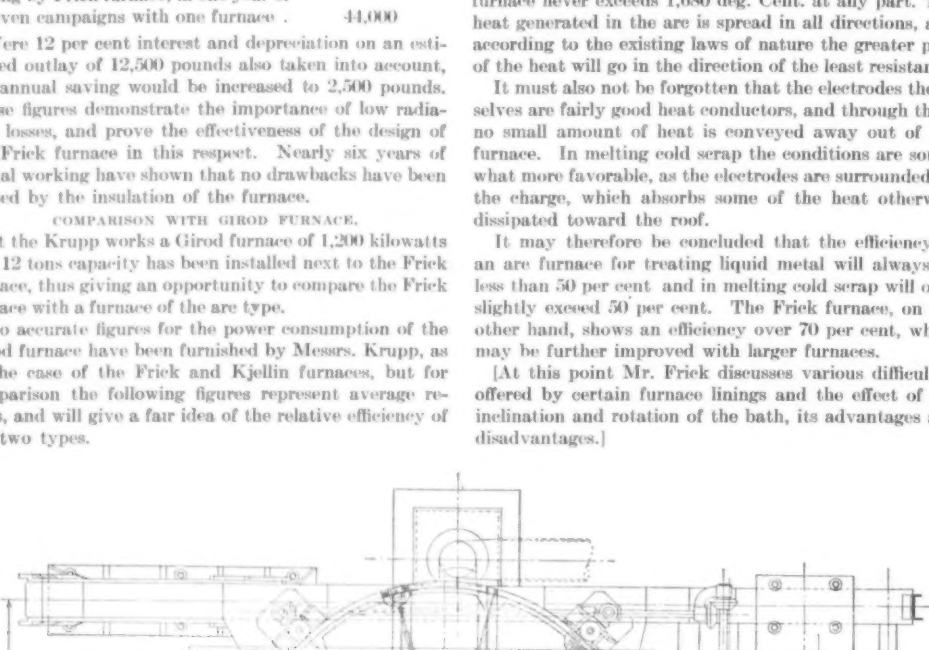


Fig. 3.—Plan of ten-ton Frick electric furnace, 1,000 horse-power.

of these reactions and of the electrical conditions. His remarks on desulphurization are expecially interesting, comparing the conditions in the induction and arc furnaces.]

METHOD OF SULPHUR REMOVAL.

One of th most valuable faculties of the electric furnace is that of eliminating the sulphur down to traces in a quick and efficient manner. This is due to the neutra' or reducing character of the furnace and to the basic lining permitting the use of a slag rich in lime. The exact way in which the el'mination of sulphur takes place is hardly yet ascer ained. The author's view is that the conditions for a quick removal of the sulphur are analogous to those for dephosphorization, and that the temperature only plays a subordinate rôle, the constitution of the slag being the mos important factor, and requiring such a composition that the slag will be eager to take up substances which will increase its fluidity.

To make the desulphurization permanent it is further necessary that the sulphur, contained in the steel as iron sulphide and manganese sulphide, should enter into a combination which will not be dissolvable in the steel. The only such known combination is calcium sulphide, CaS, the formation of which thus has to be aimed at. In the arc furnace the desulphurization is obtained by carbon according to the following reaction:

$$CaO + C + FeS = CaS + CO + Fe.$$

It has been said that calcium carbide, CaC_2, and not carbon is effective in bringing about the desulphurization in the arc furnace. This, however, does not seem very probable, there being no apparent reason why lime should be reduced, the oxygen forming CO and the calcium combining with more carbon only to give up the same carbon to other lime, and then itself combining with sulphur. On the other hand, it is evident that the same conditions which favor the formation of CaC_2 also allow the elimination of sulphur.

The presence of CaC_2 is thus only to be looked upon as a proof of the slag being completely deoxidized and able to absorb sulphur. It is, however, bad economy to try to produce calcium carbide in a steel furnace.

In the induction furnace the desulphurization is much more quickly effected by ferrosilicon, which in this reaction offers the same advantages as mentioned with regard to deoxidation. As it is wanted to form calcium sulphide, and as calcium possesses a very strong affinity for oxygen, it is not possible to expect any desulphurization in this way before the bath and the slag have become well deoxidized. Thus, before any sulphur can be removed, all the more easily reducible oxides, as phosphoric acid, ferrous and manganese oxides, must be reduced. After this has been effected the removal of sulphur probably takes place in the following manner:

The desulphurizing slag, which mainly consists of lime and fluorspar, must not be allowed during deoxidation to enrich itself too much in SiO_2, so as to maintain its tendency to increase further its content of this acid constituent. That tendency is so strong that, if the steel contains any silicon, some calcium is even reduced from calcium oxide, the oxygen combining with the silicon, and the calcium robbing the sulphides in the metal of their sulphur, according to the following reaction:

$$Si + 2CaO + 2FeS = SiO_2 + 2CaS + 2Fe.$$

It is, however, also possible that the fluorspar in the slag to some extent acts as a desulphurizer,

$$Si + 2CaFl_2 + 2FeS = SiFl_4 + 2CaS + 2Fe.$$

The silicon fluoride, being a gas, escapes from the furnace.

From experiences with an arc furnace the author has found that even with a perfectly deoxidized white and falling slag it may happen that no elimination of sulphur takes place, or that at any rate it takes place very slowly. In all such cases it was found that the slag was very high in silica through drippings from the roof of silica bricks. The probable explanation is that with too high a percentage of SiO_2 the slag has no desire to increase this percentage by giving up some of the oxygen combined with calcium, and the calcium not being liberated it cannot combine with the sulphur.

COMBINATIONS OF ELECTRIC FURNACES WITH OTHERS.

In considering the combinations of the electric furnace with pre-melting furnaces, the aim should be to make such disposition as to utilize the specific advantages of the different furnaces as fully as possible. Therefore all oxidizing reactions should, as far as possible, be carried out in the oxidizing furnace, and the electric furnace should mainly be used for desulphurization, deoxidation and alloying, or for such reactions as require a reducing or neutral atmosphere. The electric furnace may also with great advantage be used for raising the temperature of the steel from that necessary for the oxidizing reactions, up to tapping temperature. This is especially the case when the electric furnace is operating in combination with an open-hearth furnace. The efficiency of the electric furnace is not very much influenced by the temperature of the metal. A 20-ton single-ring furnace has, for instance, a maximum efficiency of 81 per cent at 1,500 deg. Cent. and of 78.8 per cent at 1,600 deg. Cent., thus a very small reduction.

In an open-hearth furnace the conditions are very different, because of the fact that the useful heat has to be transferred from the gases to the steel. With increasing temperature of the steel the transfer of heat becomes less, and finally becomes nil, when the difference of temperature between the gases and the steel has become so low as to allow only so much heat to be transmitted as is necessary to cover the radiation losses from the bottom of the surface. At this stage the efficiency of the furnace is zero. This question of the efficiency of the open-hearth furnace is of considerable importance for the appreciation of the possibilities of the electric furnace, but so far as the author knows, no complete study of the open-hearth furnace with regard to its efficiency during various stages has ever been published.

COMPARISON OF COSTS.

To bring out the economical possibilities of the combination of the induction furnace with an open-hearth furnace, the costs of treatment may be compared in a general way as follows:

Assuming an open-hearth steel, costing 16 shillings per ton to produce by the usual open-hearth process requiring eight hours, and assuming that a treatment is adopted by which the steel is transferred to an electric furnace after 5.5 hours for the final treatment: The costs in the open-hearth furnace will then be reduced from 16 shillings to $5.5 \div 8 \times 16 = 11$ shillings per ton. The cost of the treatment in a 25-ton Frick furnace, operating in connection with three or four open-hearth furnaces of the same capacity, will in case of cheap current from blast-furnace gas be about 7 shillings per ton, including the costs for the ladle for the transfer of the steel to the electric furnace, slag additions for desulphurization, deoxidizers, lining, labor, and royalty.

The total costs of production by the combined process would thus be only 2 shillings per ton higher than by the ordinary open-hearth process, and considering that such steel has been desulphurized and thoroughly deoxidized in the electric furnace, an increase of 2 shillings per ton must be considered low, and the process ought to find a wide application for certain purposes.

Although the electric furnace undoubtedly will come into extensive use in combination with open-hearth furnaces, its importance will, however, be much greater to the present Bessemer acid and basic processes. In districts rich in ores suitable for acid or basic working, it is probable that the open-hearth furnace will soon totally disappear, as the electric steel can be produced at a price equal to or less than that of open-hearth steel, and of higher quality.

The difference in cost of production between Bessemer acid and basic steel may be said to vary between 6 shillings and 12 shillings per ton. The electric treatment in the induction furnace costs from 5 shillings to 8 shillings, or possibly 10 shillings per ton, according to the amount of refining wanted, the size of the plant, etc.

MELTING FERROMANGANESE.

The advantages of using liquid instead of cold ferromanganese are mainly: quicker and more reliable deoxidation, greater uniformity in the composition of the steel, avoidance of hard spots in the ingots due to undissolved FeMn, and thus higher quality, greater security that all FeMn is absorbed by the steel, and thus less loss, which in the case of FeMn in lumps may become considerable through some of it getting stuck in the slag. The advantage of the electric furnace for the melting of ferromanganese over other furnaces is again based on its non-oxidizing atmosphere, thus avoiding considerable loss of metal.

Sleep

By W. P. Pycraft

"O sleep! it is a gentle thing, beloved from pole to pole."

REMOVED from their context, these lines of Samuel Taylor Coleridge present but a bald statement of fact. Thus isolated, however, they best serve my present purpose, which is to bring together a number of other isolated facts about sleep which are not, perhaps, commonly known.

Sleep is indeed a "gentle thing." It is the supremest form of rest. Our notions of rest during sleep, however, are likely to be a little upset when we come to survey the various postures assumed by different animals during sleep.

To begin with the human race. The majority of mankind, probably, sleep lying upon the right or left side of the body, and with the knees drawn up toward the chin. But certain African tribes, for example, lie upon the back, with the head, or rather, the back of the neck, resting on a bar of wood supported on two short pillars. The elephant apparently invariably and the horse commonly sleep standing. This is really astonishing. Apart from the apparent difficulty of maintaining the balance of the body during these long periods of unconsciousness, one would have supposed that a recumbent posture in the case of both these animals was imperative. Cattle and their kin commonly sleep lying down, and during many hours of the day they lie down, as when chewing the cud. More curious still, there are creatures which invariably sleep hanging head downward, suspended by their hind feet. The bats afford a case in point. Among the birds, we meet with the same strange habit in the little hanging parrots of India and the Malayan region. In this they differ from all other birds, which invariably sleep with the head turned tailward over the back and the beak thrust in among the feathers between the wing and the body, not *under* the wing, as is commonly believed. No explanation has ever been offered to account for this strange habit. It is followed even by the penguins, wherein the feathers are so short as to fail completely to cover even the beak. Owls are, perhaps, the only exception to the rule. And, by the way, the only other animals which thus turn the head backward after this fashion during sleep are certain peculiar tortoises known as "side-necked tortoises." Certain birds sleep while resting only on one leg. This curious pose is well seen in long-legged birds like storks and gulls. Ducks generally sleep on open water. And to avoid drifting shoreward, and therefore into the danger zone, they keep constantly paddling with one foot, so that the body is always circling round the chosen sleeping-area. The sloths sleep suspended by their feet, and the head tucked in between the fore-legs. The no less remarkable African pottos, or slow-lemurs, assume a similar pose, but they attach themselves to a vertical, instead of a horizontal, bough, so that the body rests with the head upward. No animal, save man, sleeps upon its back.

Some animals are said never to sleep, and this because the eyes are never closed. The hare, snakes, and fishes are commonly supposed to enjoy this unenviable distinction. The notion is, however, quite erroneous. Whales and their kin are often quoted as sleepless creatures. It is supposed that if they made this mistake they would promptly drown! As a rule, darkness induces sleep. With many animals, however, the reverse is the case, as with the bats and owls, for example. This reversal of the usual order has been brought about by the nature of the feeding habits.

Finally, one comes to the question: Where does sleep begin? This is by no means easily answered. One is inclined to draw the line at the insects. But since all living things, plants as well as animals, display periodical states of quiescence, perhaps we shall be near the truth in regarding sleep as universal among living things. In the case of plants, it is enforced by darkness, save in the case of many bacteria and fungi, which, like evil deeds, grow under the cover of darkness.—*The Illustrated London News.*

The Vegetable Riches of Morocco

M. PITARD, professor at the Natural History Museum of Paris, has just made a most interesting journey to Morocco. The botanical exploration of the Chaonia region has enabled him to discover the presence of 850 vegetable species, of which 657 are dicotyledons, 180 monocotyledons, 2 coniferæ, and 11 pteridophytes. This flora offers a very striking analogy with that of the Algerian Tell, and though less striking still distinctly accords with the flora of the Spanish Peninsula, which is a proof that relations relatively recent and easy existed between these two regions. At any rate, the want of numerous points in common between the flora of Chaonia and that of the Canary Isles is not a sufficiently decisive argument in favor of the non-existence of the Atlantide, for the fact is that the real Canary flora being generally composed of mountainous plants, their absence in the Plains of Chaonia is natural enough, and if they exist anywhere it is on the heights of the Atlas. —*Chemical News.*

The Fertility of the Carp

IT has long been known that certain fishes are extraordinarily fertile, and the carp, in particular, according to various estimates, produces from 100,000 to 500,000 eggs apiece. Recent counts made by Dr. Staff exceed all previous estimates and places the number of eggs of a carp at the immense number of 1,662,680. The individual on which this count was made weighed 10 pounds. Needless to say, in the ordinary course of events only a very small portion of this huge potential progeny actually survives.

AT the completion of its fiftieth volume, *The American Chemical Journal*, founded and edited by Prof. Ira Remsen, will be discontinued as a separate publication and will be incorporated, from January, 1914, with the *Journal of the American Chemical Society.*

Triumphal arch on the east side of the Court of the Sun and Stars.

The height of the archway will be ninety feet. The columns of the colonnade encircling the court will be sixty feet in height; the group surmounting the arch is composed of figures symbolical of the Orient. On the opposite side of the court will be a triumphal arch with figures typifying the Occident. The east and west arch exemplify the meeting of the East and West in the Panama Canal.

The Court of Palms.

Looking south toward the Horticultural Building at the Panama-Pacific International Exposition, San Francisco, 1915. The Italian towers at the entrance of this court will be forty feet square and two hundred feet in height. There will be two towers, at each side of the entrance of the court, and they will be identical in architecture. One of the commanding towers is seen just in the center of the illustration.

The Administration Building.

The dominating architectural feature of the Panama-Pacific International Exposition, San Francisco, 1915, the imposing tower of the Administration Building, which will lie at the south end of the Court of Sun and Stars. This tower, 400 feet in height, will be indescribably beautiful with statuary, mural paintings and mosaics; at its summit will be a grouping of statuary supporting the globe typifying the world.

Architectural Plan of the Panama-Pacific International Exposition

Conceptions Symbolized by the Buildings and Their Arrangement

By H. S. Roberts

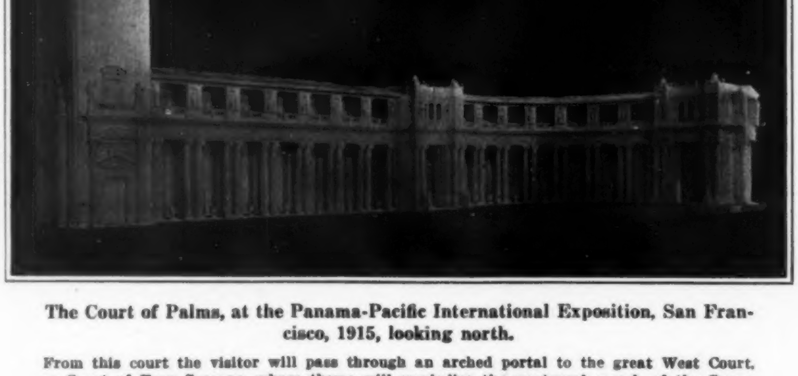
The architectural plan of the Panama-Pacific International Exposition was determined by the impressive surroundings of the site. In the cases of the expositions at Chicago and St. Louis the locations chosen were plains, with little or no rising ground in the neighborhood. But at San Francisco the site, at Harbor View, a huge basin which opens out to the north on San Francisco bay, presents vivid contrasts in surrounding hills, distant mountains, and in the harbor with its great islands. Incircling the site, which extends along the shores of the bay for fifteen thousand feet, and averages one half mile in width, the rim of the hills rises on the south, east and west to an average height of three hundred feet; to the north is San Francisco bay with its huge islands and shipping, and beyond, four or five miles distant, the hills of Marin County ascend from the water in great hogbacks, towering finally into the thousands of feet. As the traveler enters the Golden Gate he views, almost directly to the southeast, a level exposition site, set as the floor of an amphitheater and averaging about six feet above high tide. This area has been made uniformly level, about one hundred acres having been filled in by dredges.

With this superb setting it was felt that if the exposition palaces were to be set apart with comparatively wide intervening spaces between the buildings, the entire architectural composition would lose in impressiveness when compared with the massive setting provided by nature. And so, at the exposition, a block plan has been adopted, distinguished by the grouping of exposition palaces about great interior courts. The main exhibit palaces are being grouped to present from afar the effect of a single design, a great battlemented city. All told, it may be observed, there will be three great groups of buildings at Harbor View; in the center will be the fourteen buildings constructed by the exposition company; on the east this center group will be flanked by buildings of the concessions district, occupying sixty-five acres, and on the west by the pavilions of the States and nations. Both the east and west groups will be brought into harmony with the main group and the architects having in charge the construction of the buildings for the concessions wing and those having in charge the pavilions of the States and nations are co-operating with the architectural commission.

The present description concerns the center group which will occupy one hundred acres in the center of the site. The grouping will mark a unique departure in the arrangement of exposition buildings. Eight of the principal buildings will be grouped in a quadrangle, four of them facing upon San Francisco bay and four facing south toward the hills of San Francisco. The entrance between the buildings will be inter-connected by archways and great "tower gateways" interconnecting the walls of the buildings and presenting the effect of an almost continuous wall. The architecture of this outside wall is in the hands of Messrs. Bliss and Faville of San Francisco.

Flanking the great walled city on the east will be the immense Machinery Hall, the largest of the exposition buildings, 367 feet wide and 967 feet long, with three naves 126 feet high running throughout its length. On the west the center group will be flanked by the classical Palace of Fine Arts, a circular structure 1,100 feet in its outside circumference. The building, quieter in its outline than the towering center group, will have as its central motif a low dome arising from a unique base and will be separated from the center group by a great lagoon. On the south the center group will be flanked by Horticultural Hall, Festival Hall, and other buildings in a great south garden which will lie between the main group and the exposition inclosure.

If one may pick out the most distinctive feature of the architectural plan, insofar as the work of the architects is concerned, it may be said that it will lie in the three great courts which, dividing the walled city from north to south, will, with their approaches, extend from the south garden or Alameda to the esplanade



The Court of Palms, at the Panama-Pacific International Exposition, San Francisco, 1915, looking north.

From this court the visitor will pass through an arched portal to the great West Court, or Court of Four Seasons, whose theme will symbolize the westward march of the Saxon in the progress of history.

along San Francisco bay. The design of each court is in charge of a separate group of architects, and all details of arrangement and adornment have long been completed. The central court, to be known as the Court of Sun and Stars, is designed by Messrs. McKim, Mead and White, of New York. The west court, to be known as the Court of Abundance, is designed by Mr. Henry Bacon, designer of the Lincoln Memorial; and the east court, to be known as Festival Court, is designed by Mr. Louis Mullgardt, who designed the Fisheries building at the World's Columbian exposition in Chicago. The most original phase of the three courts will be that the walls of each court will be the column-screened façades of the four surrounding buildings. The walls of the buildings will in fact be the walls of the courts. Thus, each group of architects in the design of the court will design a part of each of four exhibit palaces. The plan is remarkable in that it affords each architect or group of architects the widest latitude in expression without interfering in the general architectural plan. The courts will be like great roofless rooms or patios.

The Court of Sun and Stars will be the most imposing of the court effects at the exposition. The size of the court will be 750 feet east and west and 900 feet north and south, exclusive of its opening on San Francisco bay, which will be 600 feet north and south and 300 feet in width. From the south entrance of the court one will look north across the Court of Sun and Stars to the flashing waters of the bay, fifteen hundred feet distant. In its position between the east and west courts, and also in its architectural treatment, the Court of Sun and Stars will suggest the theme of the exposition, the meeting of the East and West through the Panama Canal.

The theme will be further carried out in the sculptural works. On the east side of the Court of Sun and Stars the visitor will pass through the Arch of the Rising Sun toward the great East Court of the exposition; similarly on the west side of the Court of Sun and Stars he will pass through the Arch of the Setting Sun to the West Court. Both of these arches, one hundred and sixty feet in height, will be identical in size. Surmounting the Arch of the Rising Sun will be a grouping of statuary, comprising typically Oriental figures, elephants, camels, and mounted Arab warriors. The statuary will be of colossal dimensions, the tallest figure in the group being forty feet in height. Crowning the Arch of the Setting Sun will be figures representing western civilization, Indians, prairie schooners, pioneers, suggesting the advance of the Anglo-Saxon across the plains of America to his ultimate stand upon the shores of the Pacific. But perhaps the most charming feature of the Court of Sun and Stars will be found in an incircling colonnade to be surmounted by figures typifying the stars. These figures, each fourteen feet in height, will be crowned by star-shaped prisms four feet across. At night the prisms will reflect the rays of massed batteries of searchlights upon the roofs of the buildings.

The dominating architectural effect of the exposition will be the great Tower of Jewels, designed by Messrs. Carrere and Hastings of New York. The tower will rise to a height of four hundred feet and, located at the southern entrance of the Court of Sun and Stars, it will be seen from all points of vantage as the central theme of the main group of exposition palaces. The base of the tower, which will be one acre in extent, will be cleft by a vaulted archway 125 feet in height through which one will enter from the south garden directly upon the Court of Sun and Stars. The tower will rise in terraces ornamented with figures of early explorers of the oceans and with mounted figures suggesting adventure and achievement; at its summit it will give way to a group of statuary supporting a globe, typifying the world.

When the visitor in 1915 views the exposition group from the harbor, the effect will be like that produced by Constantinople. In the center of the group will rise the Tower of Jewels, flanked on the east and west by towers and domes rising 135, 150 and 270 feet in height; the outside walls of the buildings will be sixty-five feet in height; identical in height of the façades at the World's Columbian Exposition in Chicago. The skyline, however, will be 110 feet, as vaulted naves of this height will run through the centers of all the exposition palaces. At the point where these naves cross there will be placed great domes 140 feet in height.

As seen from the hills of the city the exposition will present a great parti-colored area, described by Mr. Jules Guerin who has charge of the color scheme as a giant Persian rug of soft, melting tones. The roofs of the buildings will be a reddish pink, the color of Spanish tile; the domes will be green, and gold and blue will be set within the recesses of the towers. The general color plan of the exposition, as a whole, will be a tawny buff, the color of Travertine stone. This shade, under the brilliant sunlight of California, gives from afar the effect of white. The shade has already been applied to one of the completed structures on the exposition grounds.

As a whole the architecture and decoration of the exposition will present a new treatment in exposition planning.

To the sculptor the Panama Exposition suggests an exalted theme, the breaking of the barrier between the oceans through the Panama Canal. The hardihood of the early explorers who sought a short cut to the Indes by way of the Atlantic, the exploits of later adventurers upon uncharted seas, the meeting of the East and West at Panama, offered fruitful themes for statuary. To the decorative artist the exposition suggests such color possibilities as exist in California, the vibrant tints of nature, the gold of the orangeries, the browns of the summer hills, the blues of the pacific. To the architect the event offers the opportunity to convey to the beholder an effect of grandeur and magnificence, but an effect which, of course, will convey in itself no specific idea, for only when architecture is presented in connection with sculpture may its intent be specific.

The sculpture is the medium through which the import of the architecture at the exposition will be conveyed, and color by day and illumination by night will but enhance, an effect which might otherwise be less appealing.

At San Francisco the architect, the sculptor, the decorative artist, and the landscape gardener have worked to produce a composite effect. The result will, it is anticipated, be marvelous. The work of all the craftsmen, the architects, sculptors, engineers, is so closely inter-related that a mention of the architectural plan would be incomplete without reference to the work of the other craftsmen. And so the architectural plan in its entirety will suggest the stupendous nature of the work at Panama, the significance of the meeting of the oceans. The exposition throughout will express the joyous spirit with which America will welcome the peoples of the world. There will be color and flowers, vast beds of flowers and decorative land effects. The exposition will be set as in a garden.

Intervention of the Number π in the Relations Between Atomic Weights

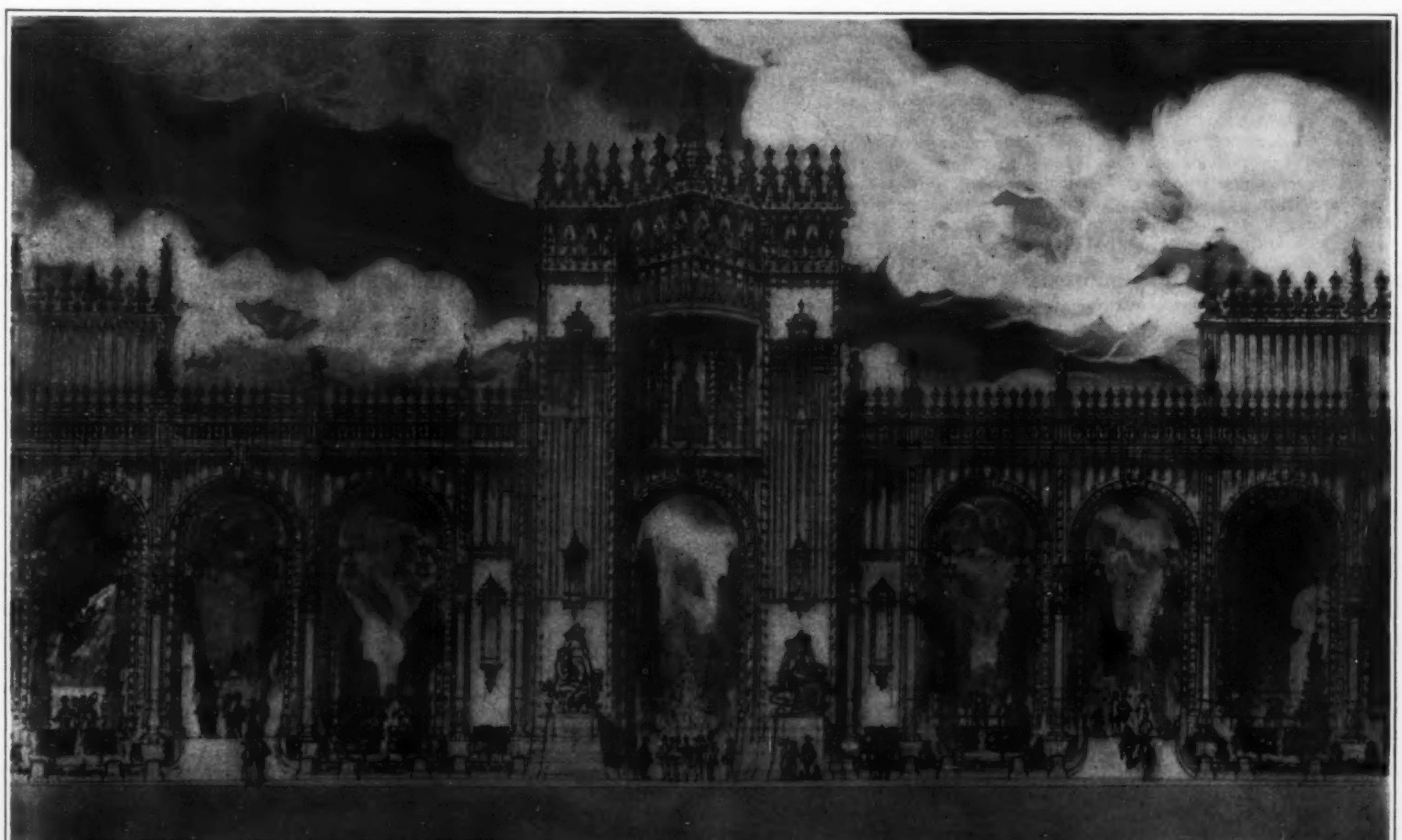
By P. Dambier

From the comparison of the atomic weights of certain elements it appears that these numbers depend upon one another by relations which involve the Number π (3.141593). The author has arrived at this result by investigating the eight elements *Cl*, *Br*, *I*; *C*, *N*, *O*, *S*, and *H*. The following are some of the values of π calculated by using the atomic weights of Guye:

$$\frac{CN}{2CN - Cl} = \frac{\pi}{2} \qquad \pi = 3.1415$$

$$\frac{NCl + 2\pi}{NH_3 - 2\pi} = 4 \qquad \pi = 3.1416$$

—*Journal de Chimie Physique.*



Façade of the superb East or Festive Court.

One of the most beautiful architectural creations of the Panama-Pacific Exposition, San Francisco, 1915. Mr. Louis C. Mullgardt, architect of the Fisheries Building at the World's Columbian Exposition in 1893, is designer of this court, which will portray the splendors of Oriental architecture.

The Condensation of Gasoline from Natural Gas*

About Two Hundred Plants in Operation in the United States

By George A. Burrell and Frank M. Seibert

In this paper are given some results of work performed by the Bureau of Mines having to do with the condensation of gasoline from natural gas.

CHEMISTRY OF NATURAL GAS.

With the growth of the natural gas gasoline industry natural gases have been classified into two divisions so called "wet" and "dry" gases, depending upon whether or not gasoline can be commercially condensed from them. The classification is exceedingly loose because natural gas mixtures may range from those containing only methane as the combustible constituent (a gas difficult to liquefy) to those in which the hydrocarbon vapors predominate and which liquefy easily. Between the two extremes there are natural gases containing the different constituents, methane, ethane, propane, butanes, pentanes, etc., in many different combinations. Some of these may not contain enough of the desirable gasoline constituents for commercial purposes, others may.

Natural gases not found intimately associated with oil are the so-called "dry" gases. Those found in the same strata with oil and in intimate contact with the same are those from which gasoline is obtained in the natural gas gasoline industry. The Bureau of Mines finds as the result of many analyses that natural gases are mixtures in which hydrocarbons of the paraffin series predominate and that small quantities of nitrogen, carbon dioxide and water vapor are present. Hydrogen sulfide is sometimes present; perhaps other sulphur compounds too. F. C. Phillips found natural gases of Western Pennsylvania, which he worked with, to contain paraffin hydrocarbons, carbon dioxide and nitrogen. Other investigators invariably report at least small proportions of carbon monoxide, hydrogen and ethylene. Experimental errors in the work easily account for these errors. The authors of this paper believe the work of S. A. Ford as showing very large percentages of hydrogen to be in error. His analyses have been quoted many times in different text books. They were made in 1885. The authors of this paper in looking over the analyses made by them of thirty natural gas samples collected from different parts of the country find the heating value ranging from 685 British terminal units to 1,577 British terminal units per cubic foot at 60 deg. Fahr. and 760 millimeters pressure. These analyses will be incorporated with many others in a government publication. These gases range from marsh gas issuing from the marsh beds, and containing only methane as the combustible gas to casing head gases that are used for lighting and heating towns. Only two of the gases, those of the highest heating value, are probably adapted for gasoline condensation. One sample contained (as shown by combustion analysis) in addition to methane, carbon dioxide and nitrogen, 75.16 per cent of ethane. The natural gas of Pittsburgh has a gross heating value of about 1,177 British terminal units per cubic foot at 0 deg. Cent. and 760 millimeters pressure.

SIGNIFICANCE OF ORDINARY ANALYTICAL RESULTS.

In the analysis of natural gases by the slow combustion method, the data obtained admit of the calculation of only two of the chief constituents. The mixture, however, may contain all of the gaseous paraffins and considerable quantities of the vapors of the liquid hydrocarbons. When the lower members of the paraffin hydrocarbons predominate, the results obtained are more accurate than when the higher members predominate. Natural gases from which gasoline can be extracted contain appreciable quantities of the liquid hydrocarbon vapors. In the analyses of these mixtures the ordinary slow combustion analysis will give only approximate results for several reasons.

First—The gas mixture often contains more than two combustible constituents.

Second—Some of the gases and vapors deviate considerably from the gas laws and their true molecular volumes[1] are unknown.

Third—So small an amount of the mixture must be used in some cases that experimental errors are greatly magnified in calculating to a percentage basis.

Typical analyses of two different natural gases follow which contain small amounts of methane and larger amounts of ethane, propane and butane with the vapors of the liquid hydrocarbons pentane, hexane, etc. These analyses serve to show how approximate a combustion analysis may be even when the analysis is carefully performed.

In the analysis of gases of this type the explosion method is entirely out of the question. The analyses were made by the method of slow combustion. Duplicate analyses were made of each sample.

SAMPLE NO. 1

	I	II
	cc.	cc.
Volume of sample taken	20.00	.19.95
Oxygen added	95.70	95.30
Total volume	115.70	115.25
Volume after burning	64.10	64.00
Contraction due to burning	51.60	51.25
Volume after CO_2 absorption	22.10	22.60
Carbon dioxide produced by burning	42.00	41.40
RESULTS OF ANALYSES.	PER CENT.	
Ethane	96.00	98.75
Propane	6.00	3.33
Total paraffins	102.00	102.08

SAMPLE NO. 2.

	III	IV
	cc.	cc.
Volume of sample taken	20.35	23.50
Oxygen added	96.15	126.75
Total volume	116.50	150.25
Volume after burning	60.10	85.30
Contraction	56.40	64.95
Volume after CO_2 absorption	10.40	28.20
Carbon dioxide produced by burning	49.70	57.10
RESULTS OF ANALYSES.	PER CENT.	
Ethane	65.85	66.80
Propane	37.50	36.50
Total paraffins	103.35	103.30

The foregoing analyses show how a small difference in the contraction due to combustion and the carbon dioxide produced will, when calculated to the same basis, affect the distribution of the paraffins and also the total paraffin content. The fact that the gases total over 100 per cent is because the correct molecular volumes of all the gases present in the mixtures are not known. For example, in the case of analyses I and II (duplicate analyses) the contraction in I is 51.60 cubic centimeters from 20.00 cubic centimeters of the original sample while the contraction in II is 51.25 cubic centimeters. This latter result, when calculated to 20.00 cubic centimeters of sample, gives a difference of 0.22 cubic centimeter from the first, which is the experimental error.

The carbon dioxide produced in I from 20.00 cubic centimeters of sample is 42.00 while that produced from II when calculated to 20.00 cubic centimeters sample is 41.50 cubic centimeters or a difference of 0.5 cubic centimeter, the experimental error.

The combined difference in the contraction and carbon dioxide change the paraffin distribution by 98.75—96.00 or 2.75 per cent in the case of ethane and 6.00—3.33 or 2.67 in the case of propane. The total paraffin hydrocarbon content is changed only by 102.08—102.00 or 0.08 per cent.

In a like manner in the case of analyses III and IV (duplicate analyses) the contraction produced in III by the combustion is 56.40 cubic centimeters with 20.35 of sample while the contraction produced in IV calculated to 20.35 cubic centimeters of sample is 56.25 cubic centimeters or a difference of 56.40 cubic centimeters—56.25 cubic centimeters or 0.15 cubic centimeters, the experimental error.

The carbon dioxide from 20.35 cubic centimeters of sample is 49.70 cubic centimeters in III while the carbon dioxide in IV is 49.44 cubic centimeters when calculated to 20.35 cubic centimeters of sample. This is a difference of 0.26 cubic centimeter, the experimental error. Here the combined difference of the contractions and the carbon dioxide change the paraffin distribution by 66.80—65.85 or 0.95 per cent in the case of ethane and 37.50—36.50 or 1.00 per cent in the case of propane. The total paraffin content is changed only by 103.35—103.30 or 0.05 per cent.

Although combustion analysis shows only approximately the quantity of paraffin hydrocarbons present, the total paraffin hydrocarbons are correct or nearly correct. The same can be said of the heating value and specific gravity as calculated from the analyses. The ascertaining of the different hydrocarbons that may be found in natural gases has long been a stumbling block to gas analysts. The ordinary eudiometer analysis offers nothing in the way of a complete separation. The total paraffin hydrocarbon content with only an approximation of the individual paraffin has been the only end attained. The authors in working on the problem succeeded in making a separation of a natural gas into its individual paraffin hydrocarbons by means of fractional distillation at low temperatures. Natural gas was first liquefied by means of liquid air and then by means of a Töpler pump, the methane was removed. The vapor pressure of liquid ethane (boiling point—93 deg. Cent.) is so small at the temperature of liquid air (—190 deg. Cent.) that two fractionations suffice to remove the methane, which was measured and analyzed. The residual gas was then subjected to a temperature of—130 deg. Cent. and as much gas as could be removed was withdrawn with the pump. The mixture withdrawn proved to be ethane and propane. At—130 deg. Cent. all the ethane (boiling point—93 deg. Cent.) and part of the propane (boiling point—45 deg. Cent.) is removed. This fraction was measured and analyzed. The residual liquid was then allowed to volatilize and was found to be propane. The proportions were then found by simple calculations. Butane was not found within the experimental error of the manipulation which was perhaps 0.2 or 0.3 per cent. Traces of butane exist in the gas, however, also of pentane and hexane. The complete analysis including the quantity of each paraffin hydrocarbon found by the above method follows. For comparison the ordinary eudiometric analysis of the natural gas is given. The natural gas is that used in Pittsburgh.

	By liquefaction and fractionation per cent	By eudiometric analysis per cent
CH_4	86.8	79.2
C_2H_6	5.7	19.6
C_3H_8	6.2	....
N_2	1.3	1.2
Total	100.	100.0

The carbon dioxide in the Pittsburgh natural gas amounts to a trace (0.03 per cent). The gas cannot be used for the commercial production of gasoline although it contains sufficient of the hydrocarbon vapors to produce some condensate (drip) in the pipe lines. This is because of the immense volume of gas passing. The gas comes from West Virginia and is typical in composition of gases from that field that are supplying many towns. The natural gas from the Hogshooter Pool of Oklahoma, some of which goes to Kansas City, contains only methane (95.4 per cent) as the combustible constituent. The rest is nitrogen and carbon dioxide (dry basis). The Bureau has the composition of the natural gases that are supplying many towns. Further work is being done by the authors on the fractionation of natural gases. More difficulty is experienced in making a separation when all of the gaseous paraffins and vapors of the liquid ones are present.

OCCURRENCE OF GASOLINE IN NATURAL GAS.

The yield of gasoline from natural gas is determined largely by the quantity of the liquid paraffin vapors in the permanent gases. Temperature and pressure conditions in the well, gasoline content of the oil, and intimateness of contact between oil and gas, all affect the yield. Such rapid expansion of a gas from a casing head may occur as to cause a heavy condensation of vapors at the casing head.

Methane (critical temperature—95.5 deg. Cent., critical pressure 735 pounds per square inch) is always in a well in the gaseous condition. Ethane (critical temperature 35 deg. Cent., critical pressure 664 pounds per square inch) exists in some wells as a gas, in others, probably as a liquid. Propane and the butane are even more easily liquefied than ethane. In gases used for gasoline production they are present as gases. In such cases reduced pressures are usually applied to the wells. The gasoline vapors are mixed with these permanent gases in the same manner that moisture exists with air.

In gasoline plant operation, the pressure applied to condense the vapors must, of course, depend on the partial pressures of the vapors in the natural gas mixture. If butane (boiling point 1 deg. Cent.) for instance constitutes twenty per cent of the mixture, there would be needed a total pressure of 75 pounds per square inch in order to have 15 pounds on the butane vapor, and cause condensation of the vapor to begin. For this reason one gas may produce condensate with 75 pounds, while another gas will need 200 to 300

*Paper presented at the 48th meeting of the American Chemical Society, Rochester, September 8–12th, 1913, and published in the *Journal of Industrial and Engineering Chemistry* by permission of the Director of the Bureau of Mines.

[1] A government publication by the authors which covers the question is in press.

pounds. In the standard type of cooling and pressure arrangement as used to-day, methane and ethane are not liquefied, but some propane and butane are. In addition the final mixture as received at the collecting tank, will contain condensed gasoline vapors, i. e., pentanes, hexanes, etc. There will also be found a portion of the gases methane and ethane dissolved in the liquids. In other words, several changes will have taken place. One has to do with the condensation of vapor, another with the liquefaction of gas and another with the solubility of the permanent gases in the liquid produced. The three changes mentioned are so intimately connected with each other that one factor cannot be disturbed without affecting the others. For instance, such a temperature and pressure could be employed as to increase the condensation of the desirable constituents (the gasoline vapors) but with increasing pressure and lowered temperature more of the undesirable gaseous constituents would liquefy. These when exposed to atmospheric conditions of temperature and pressure would immediately volatilize, carrying with them some of the gasoline constituents. At increasing pressures more ethane and methane would be dissolved. With release of pressure they too would escape.

TESTING NATURAL GAS FOR GASOLINE VAPORS.

Before plant installations are made for the purpose of extracting gasoline from natural gas an investigation of the several factors should be made. These include (1) quality of gas, (2) quantity of the gas, (3) disposal of product.

QUALITY OF GAS.

Laboratory methods in use at the present time consist chiefly of combustion tests, solubility tests and specific-gravity tests. The combustion analysis gives only a rough approximation. The specific-gravity test is much used. Natural gases may range in specific gravity from about 0.56 to 1.50, compared to air. Some gases are used for condensing gasoline that have as low a specific gravity as 0.80. All gases of this specific gravity are not adapted, however. If the carbon dioxide or nitrogen content of a natural gas is high and not known, the specific gravity test may be misleading.

Alcohol, claroline oil, olive oil, kerosene oil, etc., all have been used for determining the solubility of natural gases. The higher members of the paraffin series are more soluble in these solvents than are the lower members. The authors have used tests that consist in shaking 100 cubic centimeters of the natural gas in 50 cubic centimeters of alcohol or 35 cubic centimeters of claroline oil, and noting the loss in gas volume. The test is arbitrary. Under these conditions it was found that natural gases soluble to the extent of from 30 to 86 per cent of their volume were used for condensing gasoline. In all these tests inconsistencies have been noted, so that especially as regards the minimum specific-gravity tests and solubility numbers herein given one would not feel sure about the feasibility of plant installation.

Natural gases differ much in composition. The so-alled wet gases, for instance, might contain a very large proportion of methane, with but little ethane, propane and butane, but enough of the gasoline vapors to warrant plant installation. Another gas with the same specific gravity might contain a comparatively small proportion of methane and ethane, a large proportion of butane and propane, but not enough of the gasoline constituents to warrant plant installation. The safest recourse is to be had to some type of laboratory compressor or better still to a portable outfit consisting of gas meter gas engine, compressor, cooling coils and receiver. Such an outfit can be hauled from well to well on a wagon. Tests conducted by such a method must also be in the hands of competent persons.

TABLE I.

Laboratory Number.	Kind of Gas.	Gross Heating Value 60 Deg. F. and 760 mm., Calculated.	Specific Gravity Air = 1.	Per Cent Absorbed by 35 cc. Claroline Oil.	Composition Per Cent.							
					Air Calculated from O_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	N_2	CO_2	Totals.
2281	Natural gas from Follansbee, W. Va.	2239	1.41	83.6	....	...	21.4	78.2	..	0.4	(a)	100.0
2284	Residual gas after 50 lbs. compression. Product has been removed	2295	1.38	82.0	....	...	26.6	72.8	..	0.6	(a)	100.0
2286	Residual gas after 250 lbs. compression. Product has been removed	1913	1.15	63.6	....	...	77.3	22.0	..	0.7	(a)	100.0

(a) Trace of CO_2 present. Gas is from 75 producing wells and is withdrawn under a reduced pressure of 20 inches of mercury. The gasoline is blended with low-grade refinery naphtha and then marketed.

QUANTITY OF THE GAS.

Many plants are in operation working on as little as 125,000 cubic feet of gas per 24 hours. Some are workings on as little as 40,000 cubic feet. These latter are largely experimental. A fair sized plant to handle 125,000 cubic feet costs about $10,000. There are probably 200 plants in the United States making gasoline from natural gas.

VALUE OF RESIDUAL GASES.

Residual gases left after plant operation are of high heating value, unless contaminated with air. Air may leak into the pipes due to reduced pressure on the pipe lines (as much as 25 inches of mercury). In one case the authors found that a residual gas had a heating value almost twice as high as the heating value of the Pittsburgh natural gas. According to the facts already presented the residual gas is bound to be a rich gas, because the methane and the ethane are not liquefied, and only a portion of the propane and butane. Neither are all the gasoline vapors condensed. Air may appreciably ower the value of the gas, however. Some residual gases contain 40 to 50 per cent of air.

DEPLETION OF THE RESIDUAL GAS AS REGARDS QUANTITY.

To give exact figures for the quantity of gas and vapor that disappear from the raw gas in plant operations is impossible. If four gallons of condensate are produced from each 1,000 cubic feet of natural gas, about 140 cubic feet of gas per 1,000 may disappear. This figure is based upon the equivalent of liquid butane, pentane, etc., in cubic feet of gas.

The following tables show the laboratory tests conducted on gases from two plants at various stages of plant operation. The Bureau has many more.

Table I gives the results of the analysi of the natural gas used by a plant near Follansbee, W. Va. The analysis, specific gravity and cla oline absorption show this to be a rich gas. I will be seen that but little difference exists between the composition of the crude gas before and after it has been compressed to 50 pounds per square inch. It is only after compression to 250 pounds per square inch and cooling, that the composition of the gas mixture changes appreciably. The high heating value of the residual gas is apparent.

Table II shows the results obtained from a small plant near McDonald, Pa. This is not a very "wet" gas. Its claroline absorption number is rather low. It is probably near the lower limit of a gas adapted for the condensation of gasoline. The composition of the gas does not change to a very marked degree after it has been compressed to 80 pounds per square inch.

NOTE.

The foregoing is abstracted from a bulletin covering in greater detail the condensation of gasoline from natural gas. This bulletin is in press. It treats of the waste of natural gas, status of the natural gas gasoline industry, future of it, utilization of casing head gas, occurrence of gas and oil, use of gas from flow tanks, value of plant equipment, chemistry of natural gas, occurrence of gasoline in casing head gas, gasoline plant operation, testing natural gas for gasoline, value of residual gas, air in the gas, life of wells, handling and blending the condensate, and the marketing of the product.

TABLE II.

Laboratory Number.	Kind of Gas.	Gross Heating Value 60 Deg. F. and 760 mm.	Sp. Gr. Air = 1.	Per Cent. Absorbed by 35 cc. Claroline Oil.	Composition Per Cent.							
					Air Calculated from C_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	CO_2	N_2	Totals.
2809(b)	Natural gas, McDonald, Pa.	1719(a)	1.01	38.5	....	2.7	96.1	....	..	1.0	0.2	100.0
		1204(b)	....	27.0	30.1	1.9	67.3	....	..	0.6	0.1	100.0
2807	Residual gas after 20 lbs. compression product has been removed	1233	....	30.1	29.0	0.7	69.6	....	..	0.6	0.1	100.0
2809	Residual gas after 80 lbs. compression, product has been removed	1164	....	25.0	30.0	7.2	62.0	....	..	0.7	0.1	100.0

(a) This analysis calculated air-free to show the composition of the crude gas. (b) Actual composition of gas delivered to the compressor.

The Light Energy Required to Produce the Photographic Latent Image

In a recent copy of *Nature*, P. G. Nutting makes some interesting reflections on the light required to produce a latent image on the photographic plate.

"The energy per silver grain may be roughly calculated without difficulty, and the calculation leads to some interesting conclusions regarding the nature of the latent image.

"Consider an exposure sufficient to produce a deposit of unit density, that is, one which will transmit but one tenth of the incident light. A negative has unit density when the silver deposit is 10 milligrammes per square decimeter, or 0.1 milligramme per square centimeter. (Sheppard and Mees, "Investigations of the Theory of the Photographic Process," p. 41). This amount of silver represents roughly 10^{18} molecules, or 10^7 grains 3 μ in diameter. Now the amount of light energy required to produce an exposure giving unit density is of the order of 10^7 watt-seconds (ergs) per square centimeter, and therefore 10^{-14} ergs per grain, or 10^{-26} ergs per molecule. The probable uncertainty in these values is not greater than a factor of 10.

"The effect of the light on the plate is to permit the chemical reduction of silver halide to metallic silver with an additional expenditure of energy less than that required to reduce the unexposed silver bromide. Development we know to proceed by whole-grain units, hence we reason that one molecule in a grain (10^{12} molecules) is so affected by exposure that the whole grain is developable.

"The simplest assumption to be made is that one electron per grain is detached from one molecule; such a liberation would require (Davis, *Phys. Rev.*, xx., p. 145, and others) 5×10^{-12} ergs, or less (*Astroph. Journ.*, xxi., p. 404), a quantity consistent with that calculated above from the known exposure and mass of silver. Hence the hypothesis is reasonable that the latent image consists of halide salt in each grain of which one electron has been liberated by exposure to light."

Dwarf Plants and Monstrous Flowers

M. J. A. Urbain, Professor of Chemistry at the Sorbonne, has had the idea of making seeds germinate after having deprived them of their albumen. Thus, by his own will, he obtains monstrous vegetables. His work is returned in a paper read before the Academy of Sciences by the eminent Professor of Botany, M. Gaston Bonnier. Evidently the albumen of a seed is not its essential part; albumen is only an alimentary reserve destined to feed the young plant until its radicle has become strong enough to seek for its food itself. But can the young plant do without this alimentary reserve? M. J. A. Urbain shows that, if put to the test, it can do so, but not without suffering from the privation. M. Urbain's experiments have been made with seeds of the Palma Christi, the poppy, etc. These seeds deprived of their albumen germinated like normal seeds, but produced dwarf, stunted plants with modified leaves and often monstrous deformed flowers. This research of M. Urbain goes to prove the possibility of creating monstrous plants at will.

In the same way the late Camille Daresle produced, at will, monstrous chicken by interfering with the normal evolution of the egg, either by varnishing a part of its surface, or by exposing it to a too strong heat.—*Chemical News.*

Ernest Solvay, Soda King

Great as Inventor, Sociologist, and Philanthropist

FEW chapters in the history of industrial chemistry are more replete with incidents of human interest than that which relates to the development of the modern methods of manufacture of soda. Many years ago such comparatively small quantities of sodium carbonate as the market called for were obtained from the ashes of certain plants, chiefly barilla and kelp. But toward the last quarter of the eighteenth century the inadequacy of this supply began to make itself felt and in 1775 the French Academy of Science offered a prize of 2,400 livres for a commercially successful process of manufacturing washing soda from common salt, inasmuch as Duhamel had some forty years previously established the identity of the base of common salt and washing soda.

The problem set by the French Academy was solved with brilliant success by Leblanc, a figure that stands out in the annals of history as one of the martyrs of science. Leblanc was by training a surgeon, and not only a contemporary but a fellow-student of Lavoisier. The fundamental principles of the Leblanc soda process are known to all: Common salt is converted into sodium sulphate (salt cake) by the action of sulphuric acid. The salt cake is then furnaced with carbon (coal) and limestone, with the production of sodium carbonate and calcium sulphide. From the resulting mass the sodium carbonate is extracted by lixiviation with water.

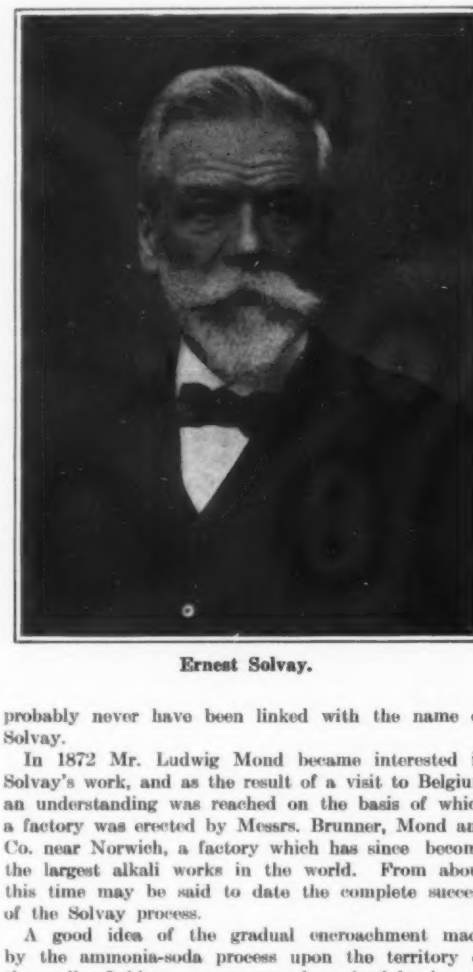
Leblanc's invention was made at a stormy period in the life of the French nation. The Duke of Orleans, to whom Leblanc was at the time surgeon, was, during his more fortunate days, the associate and patron of Leblanc. But during the evil days of 1793 disaster came upon him, he was arrested by the *comité du salut publique* and executed on November 6th of the same year. Leblanc's patent was canceled by the state and the inventor lost everything that he possessed. Notwithstanding all the sufferings thus brought upon him by the newly formed government, he showed himself a highly patriotic and public-spirited citizen by fulfilling many important functions for the state, for which he received no reward whatever. "His last public office," says Lunge in his Handbook of Sulphuric Acid and Alkali, "was that of Member of the Council of Seniors for the Department of Paris in 1798; his daughter fell ill and died of fright at that dangerous election. But all this brought him no income. He had been deprived of all means by the confiscation of the St. Denis works and was reduced to bitter poverty, while at other places, and even at St. Denis itself, factories were erected in order to utilize his process, declared to be public property."

In 1801 his soda works, which had fallen into ruin and had become worthless, were restored to his possession by the state, and an utterly inadequate indemnity of 52,000 francs was adjudicated to him, an indemnity which, however, was never paid. The prize which had been offered by the Academy of Science for the solution of the problem so brilliantly solved by Leblanc was never awarded to him. Instead of this in 1799 the miserable sum of 3,000 francs was voted to him as a national recompense, and, as if this were not enough humiliation and ingratitude, of the sum nominally awarded to him only 600 francs were actually paid. On January 6th, 1806, Leblanc died by his own hand, and the remains of one of the greatest industrial chemists in France rest in an unknown grave.

It is a relief to turn from such a dark chapter in the history of applied chemistry to another, closely related but fortunately as bright and inspiring as the story of the originator of the Leblanc process is dark and depressing. By the very circumstances of his birth and breeding Ernest Solvay seemed to be predestined for the life work which he has been carrying on with such brilliant effect for many years. Ernest Solvay was born in 1839, the son of a small manufacturer of salt, the refined product being obtained by evaporating a solution of crude rock salt. Thus his early associations were closely bound up with one of the principal raw materials of the process which later made him famous. But destiny favored him further than this. One of his uncles was manager of a gas works and took him on as assistant in 1859. Here one of his tasks was to find some application for gas liquor, which, as the reader knows, consists largely of ammonia and ammonium salts. In the course of his experiments along this line, Solvay "discovered"[1] the fundamental reaction of the ammonia soda process, the formation of sodium bicarbonate by the action of ammonium bicarbonate upon brine. His early associations with the manufacture of salt and his later connection with the ammonia recovery in gas works thus served as the nucleus from which grew his revolutionary innovations in the process of manufacturing soda.

[1] Others had made the same observation before him.

In 1861 Solvay obtained a Belgian patent for his invention, which he immediately proceeded to carry out on an industrial scale, his efforts being rewarded with encouraging success. His attempts to sell his process, however, proved vain. By a stroke of good fortune he became acquainted about this time with a certain lawyer, Eudore Pirmez, who subsequently became Minister of State of Belgium, and who entered into an association with Solvay for the further pursuit of his experiments. Many discouragements had to be met before the undertaking was brought to a successful issue. Had it not been for a dogged determination and blind faith in his invention on the part of Solvay, and for some fortunate assistance received from some members of his family, an Ammonia-Soda Process might have come into existence, but it would probably never have been linked with the name of Solvay.



Ernest Solvay.

In 1872 Mr. Ludwig Mond became interested in Solvay's work, and as the result of a visit to Belgium an understanding was reached on the basis of which a factory was erected by Messrs. Brunner, Mond and Co. near Norwich, a factory which has since become the largest alkali works in the world. From about this time may be said to date the complete success of the Solvay process.

A good idea of the gradual encroachment made by the ammonia-soda process upon the territory of the earlier Leblanc process may be gained by inspection of the following table taken from Lunge's "Manufacture of Sulphuric Acid and Alkali," 1911, vol. 3, page 15:

Years.	World's Production of Soda-ash.	Of this was made by the		Average Price of Soda-ash in Europe per Ton at Works.
		Leblanc Process.	Ammonia Process.	
	Tons	Tons	Tons	Dollars
1850	150,000	150,000	0	140
1863	300,000	300,000	0	90
1864–68	375,000	374,000	300	80
1869–73	450,000	447,000	2,600	56
1874–78	525,000	485,000	40,000	56
1879–83	675,000	545,000	136,000	34
1884–88	800,000	435,000	365,000	24
1889–93	1,025,000	390,000	635,000	23
1894–98	1,250,000	265,000	985,000	22
1902	1,760,000	156,000	1,616,000	22

More fortunate than his ill-fated predecessor Leblanc, Solvay has been rewarded for his signal services to the needs of humanity by the attainment of a large fortune. But like his predecessor he has shown himself a man of the highest public spirit and philanthropic virtue. It is said that, while circumstances forced Ernest Solvay into a life of industrial activity, his deepest and most fundamental impulses were toward the cultivation of pure science, and in particular of sociology and related subjects. While Solvay has been prevented by his intense activity in industrial pursuits from following his natural bent as a creative worker to the extent that he would have wished, he has nevertheless given to the world several highly original publications in the field of social energetics, a field which remains to the present day almost untilled but for the occasional labors of such men as Solvay, Winiarsky and, perhaps we should add, Pareto. That this field is destined in the future to rise to the highest importance few who have given it any thought can doubt. And it is therefore with the greatest satisfaction and a deep sense of gratitude that we acknowledge our debt to Solvay. He, finding the bulk of his energies diverted into other channels, liberally placed some of the resources sprung from his industrial activities at the disposal of those who might have more leisure, though less means, to give to the study of social energetics and allied subjects. It is thus that the Solvay Institute in Brussels was founded.

But Solvay's munificence in assisting the progress of science has not been restricted to the foundation of the institute that bears his name. The University of Brussels reveres him as one of its greatest benefactors, and at the recent fiftieth jubilee of the practical realization of the ammonia-soda process, a jubilee which approximately coincided with the seventy-fifth birthday of Ernest Solvay, gifts aggregating to 5,000,000 francs were made to various institutions by the veteran inventor. The Institute of Applied Chemistry of the Faculty of Sciences at Paris received 500,000 francs and the same sum was allotted to the University of Nancy, to create a chair of electro-technics. A fund of 500,000 francs was also put aside for a four-yearly prize to be awarded by the International Congress of Hygiene for researches in transmissible diseases. On the occasion of the jubilee Ernest Solvay delivered an enthusiastic eulogy of pure science and its results and made the interesting avowal that the pursuit of science had been the golden dream of all his life, and had it not been for the necessity of providing for a family, he would probably have taken it up as a profession.

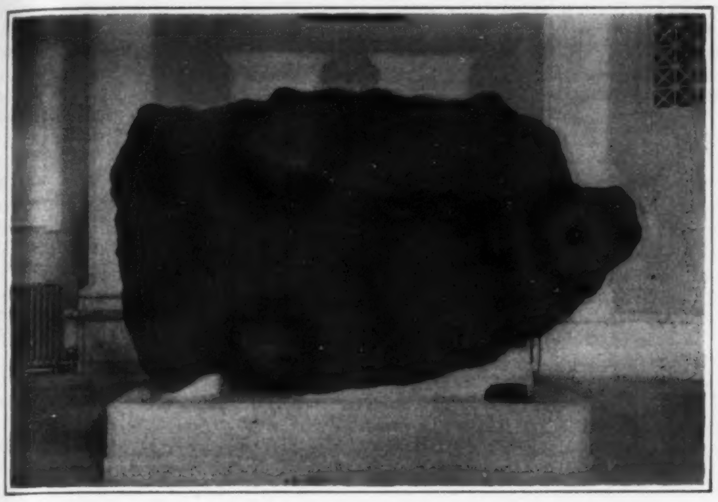
Many have been the honors bestowed upon Ernest Solvay, as is due to a man of his attainments and worth. On the occasion of the fiftieth jubilee of the ammonia-soda process King Albert of Belgium named him Grand Officer of the Order of Leopold.

Wireless Telegraphy Stations

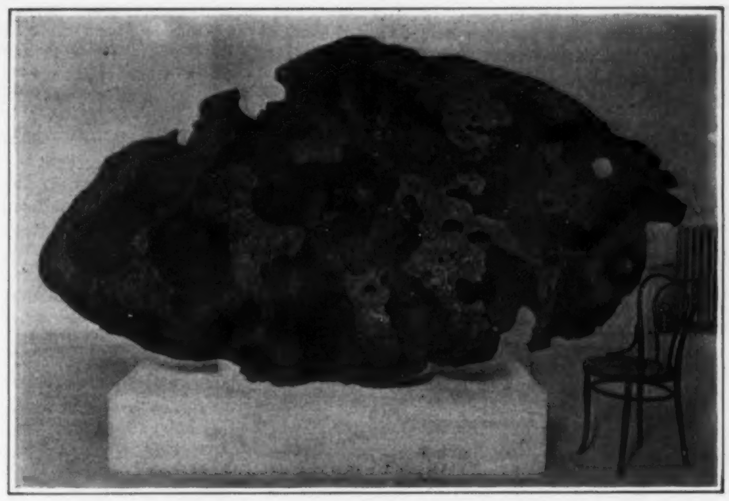
AT the present moment there exist on the surface of the globe 230 radiotelegraphic stations open to the public; they are to be found in the following places:—Canada 32, England 25, Russia 22, Germany 20, Italy 20, Brazil 16, East Indies 11, Spain 9, and France only 8. Over the different seas of the globe 1,200 mercantile vessels are navigating provided with wireless telegraphy. Here, again, France with 90 vessels comes far behind England (590) and Germany (253). The majority of French ships provided with apparatus for free communication belong to the two ports of Marseilles (46) and Havre (29). However, it is to be remarked that Marseilles, although possessing more than half the ships provided with wireless telegraphy apparatus, has, as yet, no central station, and from this point of view is tributary to the station of Sainte-Marie-de-la-Mer, whence the radio-telegrams are transmitted by telephone. To indicate the development of this new mode of communication and the necessity of endowing Marseilles with a central station it suffices to give the number of messages received: 22 in 1908, 2,393 in 1910, 6,151 in 1911, 8,217 in 1912. These figures are sufficient without further comment.—*Chemical News.*

The Last Two Comets

M. CHAUFFARDET, of Besançon, has just made a study of the last two comets that approached our world in 1913. The last is quite recent. Russian astronomers took it for a planet of the eleventh magnitude, and thought they had made a fine discovery. It was, however, a false joy. It was an old acquaintance—a periodical comet that has come to visit us for the third time since 1889. Its periodicity is then only of eight years. This, for a comet, is but a very small orbit, which accounts for its having been taken at first for a planet. The mistake is explained by the presence of a very small neuclus with very distinct outlines, and which was visible before the appearance of the tail.—*Chemical News.*



Great meteorite brought by Peary from Cape York, Greenland.



The sixteen-ton Willamette meteorite found at Portland, Oregon.

Meteorites*

The Carriers of Messages from Other Worlds

By H. B. Collier

LIKE a sentry on his beat, the earth yearly makes his round, and while he pursues his course at seemingly reckless speed he is met with a storm of missiles as from an unseen enemy.' The fusilade is never-ceasing, though waning at times to desultory shots and then again waxing into the fury of a battle.

Yet the little earth rolls majestically onward, quite unconcerned with this puny opposition. And like soldiers in an armored train heedless of the little bullets pattering on the sides, we sit behind our armor of air and fear not the celestial projectiles. Careful calculations show that probably as many as twenty million of these enter the earth's atmosphere every day.

We have reason to feel the utmost confidence in this armor. It has stood the test of centuries successfully. For how many of these missiles think you have succeeded in piercing this shield of air and reaching the earth in recognizable form? So far as we know, the record is about 700. We are undoubtedly well protected. Million after million of meteorites every hour of the day and night, come speeding toward us only to become dissipated or consumed in our atmosphere, by friction created through their own excessive speed. The ocean floor is covered with a thin layer of the ash.

We find these few hundred objects intensely interesting subjects of study. They bring to us messages of other worlds. They are the envoys of the celestial domains, coming to us laden with gifts to science. We welcome them.

I hold in my hand a meteorite. It is a world. The myth of Atlas supporting the earth becomes in the light of knowledge more of a possibility, a reality. Callous indeed are we, if, as we gaze upon this little world, our minds are not stirred with wonder and conjecture as to its former home, its travels, and its experiences. Could we but open the pages of its history and even partly satisfy our curiosity! But no; the storehouse is locked and we have not the key to the inner chambers. Our scanty knowledge permits us to secure but little.

But a century ago the scientific and even the popular world scoffed at the idea that masses of matter could come from outer space and strike the earth, in other words that stones could possibly fall from the sky. Even to-day there is much misinformation current regarding their character and the conditions of their fall.

Arguments which form strange reading at the present day were advanced by eminent scientists against the idea that bodies could come to the earth from space, a number of French scholars being particularly vehement in denying such origin. The famous chemist Lavoisier was one of a committee who presented a report in 1772 to the French Academy regarding a stone claimed to have fallen some four years previously at Luce. The report stated that the stone was an ordinary one but that "It had been struck by lightning." It was, however, a true meteorite.

Early historians mention several stones which had been seen falling from the sky, Livy and Plutarch in particular relating these facts. Among the list was one stone which had fallen in Phrygia and had been kept there for centuries until in 204 B. C. it was removed to Rome with imposing ceremonies. They also tell of a shower of stones near Rome in 652 B. C. and a stone that fell in Thrace in the fifth century B. C. The image of the goddess Diana, the famous shrine at Ephesus, is said to have fallen down from Jupiter, and was probably a true meteorite.

Quite naturally the primitive peoples looked upon the stones falling from the sky as being of miraculous origin and in consequence were led to consider them as objects of worship. Indeed, certain tribes and nations, that could not be considered primitive, in India, China and Japan, have viewed these articles with awe and reverence. Rev. George McDougall tells us of the strange fascination the "Victoria" meteorite held for the Northwest Indians of our own land. They looked upon its removal as most likely to result in fearful consequences to them. It was to them a sort of god, a guardian. It had come to them from the heavens, and as its profile bore the remarkable configuration of the face of a man, we do not wonder at the influence this wielded in the Indian tribes of the West.

It was not until almost the close of the 18th century that we find any intelligent efforts made to ascertain the real facts about these falling stones. In 1794, on the 16th of June, a shower of stones fell at Siena in Italy and the occurrence is thus described by Sir William Hamilton, in connection with his account of an eruption of Vesuvius. (From *Philosophical Transactions* of the Royal Society of London.) "I must here mention a very extraordinary circumstance indeed, that happened near Siena in the Tuscan State, about eighteen hours after the commencement of the late eruption at Vesuvius on the 15th of June, though that phenomenon may have no relation to the eruption; and which was communicated to me in the following words by the Earl of Bristol, Bishop of Derry, in a letter dated from Siena, July 12th, 1794: 'In the midst of a most violent thunder storm about a dozen stones of various weights and dimensions fell at the feet of different people, men, women and children; the stones are of a quality not found in any part of the Sienese territory; they fell about eighteen hours after the enormous eruption of Vesuvius, which circumstance leaves a choice of difficulties in the solution of this extraordinary phenomenon; either these stones have been generated in this igneous mass of clouds, which produced such unusual thunder, or, which is equally incredible, they were thrown from Vesuvius at a distance of, at least, 250 miles; judge then of its parabola. The philosophers here incline to the first solution. I wish much, sir, to know your sentiments. My first objection was to the fact itself; but of this there are so many eye-witnesses it seems impossible to withstand their evidence, and now I am reduced to a perfect scepticism.'

"His Lordship was pleased to send me a piece of one of the largest stones, which when entire, weighed upwards of five pounds. I have seen another that has been sent to Naples entire and weighs about one pound. The outside of every stone that has been found, and has been ascertained to have fallen from the cloud near Siena, is evidently freshly vitrified, and is black, having every sign of having passed through an extreme heat; when broken the inside is of a light grey color mixed with black spots, and some shining particles, which the learned here have decided to be pyrites, and therefore it cannot be lava, or they would have been decomposed."*

Scientists are sometimes very hard to convince and some of that day contended that the Siena stone had been formed by the condensation of the particles of dust in an eruption cloud from Vesuvius. Even though the largest stone weighed 7½ pounds and Vesuvius was so distant, the theory was quite unshakable. In the following year, 1795, in Yorkshire, England, a 56-pound stone fell almost at the feet of a laborer. Still this was not sufficient to dislodge from the minds of its originators the theory of condensation. But in 1798 out of a cloudless sky in India came a ball of fire. A series of heavy explosions followed, and a shower of stones fell to the earth. Again in 1803 near Paris, France, after the passage of a swift-moving ball of fire an explosion was heard over an area of 75 miles in diameter. Immediately following this, there fell some two or three thousand stones within an area of six by two miles. This was indisputable proof. Here again the sky was perfectly clear and competent scientists immediately investigated all the circumstances.

Of the meteorites in existence to-day the oldest of which we have an exact record fell in 1492, on November 16th, in Alsace, Germany. The record states that between 11 and 12 o'clock in the forenoon, with a loud crash of thunder and a prolonged confused noise heard afar off, there fell, at the town of Ensisheim on the Rhine, a stone weighing 260 pounds. A child saw it fall in a wheat field, and when they located it they found it had penetrated the earth to the depth of a man's stature. King Maximilian, who happened to be at the town just then, ordered the stone conveyed to the castle, and after breaking off two pieces, one for himself and one for Duke Sigismund, of Austria, directed that the big stone should be suspended in the parish church. There it remained for three centuries, when for a time during the French Revolution it was carried off to Colmar, but was eventually restored, and to this day Ensisheim rejoices in the possession of this remarkable aerolite.

Whence come the meteors? The answers are numerous and varied. If we accept the theory of a small group of scientists, among them Mr. W. H. Pickering, we will have to believe that the moon was thrown off from the earth ages ago; and in such a gigantic eruption innumerable small pieces were loosened and flung into space. Another school claim the sun as the source, its enormous eruptive power being able to overcome the force of gravity and in consequence these millions of small bodies are flung about the solar system at random apparently. But when it is considered that the astronomer of to-day foretells the date of arrival of "showers" of meteors, in view of his knowledge of the path of a comet, we must accept the relationship existing between comets and meteors. The once majestic comet has become dissipated into innumerable bodies, each a small world, which trail along in the original path. Fully 100 of such paths are catalogued to-day. And we must, therefore, admit that it is most likely the major number of meteorites were formerly associated in some manner with comets.

There are at present some 700 meteorites, or 700 distinct falls, treasured and jealously guarded in museums and collections. They vary in weight from a fraction of an ounce to that of Ahnighito, the wonderful Green-

*Reproduced from the *Journal* of the Royal Astronomical Society of Canada.

land siderite, with its 36½ tons.

Before attempting a description in detail of some of the most famous meteorites let us look for a few moments at the usual classification made according to mineral composition, and to some of the characteristic features.

There are three general classes:

1. Siderite or iron meteorite, which consists essentially of an alloy of iron and nickel (Gr. sideros—iron).
2. Siderolite or iron-stone (Gr. sideros and lithos).
3. Aerolite or stone, meaning an "air stone."

The line of demarkation between these classes is not always sharp, and again within these general divisions there are many subordinate classifications.

Meteoric masses are probably extremely cold out in space. But when they enter the earth's atmosphere at high speed the friction with the air combined with the enormous pressure raises the temperature of the surface to the melting point and a state of incandescence, producing a volume of dazzling light. Careful observations lead to the statement that a speed of from 20 to 50 miles per second is common. Thus only a period of two or three seconds occurs between glacial cold and the surface of the earth, if the meteorite should be of sufficient size originally to survive such a journey. And it is very probable that the interior of the meteorite attaining the earth does not even become warm. The Dhurmsala meteorites fell in moist earth, appearing as a dazzling ball of fire. An hour afterward they were found, and were coated with frost, showing the nature of the former habitat.

The rapid heating of the exterior and the consequent extremes in temperature between various parts of the meteorite, combined with great pressure on the front or face, and a vacuum behind, generally leads to rupture before reaching the ground. The stony meteorites are particularly prone to such. The rupture is usually accompanied by one or possibly a series of very loud, sharp detonations sometimes heard a hundred or more miles away. The siderites seldom burst, only six such having ever been recorded.

While some forty elements are said to occur in meteorites, the eight most abundant are found in the following order: iron, oxygen, silicon, magnesium, nickel, sulphur, calcium and aluminium. Among the most common elements are many which have a wide distribution and exist in great quantity on our own planet. But in the compounds there is marked dissimilarity. On the earth "free quartz" is the most prevalent compound, entering into the composition of such common rocks as felsite, syenite, gneiss, granite, etc. But this is never found in meteorites. And in meteorites we get compounds unknown to our mineralogy such as troilite, a combination of sulphur and iron. There is also schreibersite, a phosphide of iron, nickel and cobalt, a generally disseminated constituent of siderites and forming some of the shining lines to be seen in etched sections.

The iron of meteorites is always very distinctive, as it is not free, but found as an alloy with from 6 per cent to 20 per cent nickel. This alloy is usually of a crystalline character, and when cut, polished and etched with acid, a beautiful network of lines is shown varying with the crystalline character of the mass. This network is called "Widmanstätten" figures or lines from the name of their discoverer. When these figures are strongly developed the meteoric origin cannot be questioned, though their absence does not necessarily disprove such origin.

Troilite, which is a very common constituent of meteorites, is generally considered to be the simple sulphide of iron, FeS, though the exact chemical composition is in doubt. This is usually in the form of nodules, plates or rods, and decomposing readily during flight, leaves the remaining mass with unique markings.

Of great scientific value is the fact that hydrocarbons of various kinds have been found in meteorites. Since they are readily combustible or volatile, it proves that they have not been subjected to great heat. Furthermore, the existence of hydrocarbon compounds leads to some speculations as to the associations with life of some kind, as it is usually thought organisms are necessary to the formation of such on the earth's crust.

I have been particularly interested in the collection of meteorites in the American Museum of Natural History, New York. Money has been lavishly spent during the last few years to make it the largest and most complete in the world.

Of special interest is the group of three comprising the "Cape York Meteorites."

Commander Robert E. Peary in 1894, while exploring the Arctic regions, was guided by an Eskimo named Tallakoteah to see the "Saviksue" or great irons on the north coast of Melville Bay, near Cape York, Greenland, 76 deg. north latitude. Each had been given a name suggested by its shape, the "Dog," the "Woman" and the "Tent." The following year Peary returned to remove the meteorites. The "Dog," weighing 1,100 pounds, was soon transported to the ship. But the 3-ton mass, the "Woman," arrived there only with great difficulty and much excitement. A large cake of ice was used as a ferry between the shore and the vessel. At the ship's side tackle was being adjusted when suddenly the ice broke in pieces. For the moment all seemed lost. Enough of the tackle however clung until a safe adjustment was made.

Four miles distant on an island lay the "Tent," which was found to weigh no less than 36½ tons! Equipment which he did not have was necessary to handle so great a mass. In 1906 Peary made a special voyage to the North for this prize, but was unsuccessful. A third effort was necessary and in 1907 success was finally achieved, the ship "Hope" bringing to New York city the largest meteorite in the world.

In honor of his daughter who was born within the Arctic Circle the great iron was named "Ahnighito," this being Miss Peary's Eskimo name.

"Ahnighito" measures 10 feet 11 inches by 6 feet 9 inches by 5 feet 2 inches.

These three meteorites are very similar in chemical composition, averaging about 91 per cent iron, 8 per cent nickel, with small quantities of cobalt, copper, sulphur, phosphorus and carbon. This similarity coupled with their close proximity indicates that they were of the same fall.

How long since these meteorites came to earth is not known. It may be hundreds of years, possibly thousands. It was a popular belief that these masses or iron furnished the Eskimos with material for their knives and other weapons. I failed to find any indications where any portions seemed to have been removed. In fact, it would require a machinist's equipment to obtain even a fragment.

As to the value of these three irons I learn from a private source that Mrs. Jesup purchased them from Commander Peary, or rather "Mrs. R. E. Peary," for the sum of $40,000, and then presented them to the Museum.

Probably the most remarkable and unique meteorite in existence is the Willamette, also in the collection of the American Museum. It is very large, weighing 31,107 pounds or nearly 16 tons and measures 10 feet by 6½ feet by 4 feet 3 inches.

The observer is first impressed by its massiveness, but this soon gives place to wonder and amazement as he notes the deep pits, the series of great hollows, and the "drill holes" so distinctive of Willamette.

One side, with its broad shallow hollows, gives clear evidence of having been the "brustseite," or front, of the meteorite as it sped through the air, the friction with the atmosphere causing the surface metal to melt and flow. The other side is most irregular, having great pot-like pits a foot or more in depth, apparently caused by rusting as the meteorite lay on the ground where it fell. Evidently these cavities were formerly occupied by troilite, a sulphide of iron which is comparatively easily decomposed.

One could readily be excused for thinking that a skilled machinist had been at work with a 2-inch drill as he views a number of cylindrical holes a foot or more in depth. These were the former home of rod-like masses of the troilite.

The history of Willamette is very interesting. It was in the autumn of 1902 when two prospectors looking for gold and silver ore indications, out in the forest about 19 miles south of Portland, Oregon, came upon this mass of iron quite buried in the earth. The meteoric character was soon ascertained. To move the 16-ton mass was a problem, but to get it to the finder's ranch a mile distant without allowing the owners of the land where they were to become aware of the fact, presented additional difficulties.

A crude wagon was constructed using cross-sections of a large tree for the wheels, and by much labor and remarkable ingenuity the meteorite was transferred to the desired spot.

The owners of the forest eventually learned the facts and instituted suit in the courts for recovery. A bitter fight was there waged which ended in victory for the plaintiff.

Chemical analysis shows the meteorite to contain about 91.55 per cent iron and 8 per cent nickel. A polished and etched surface shows rather broad Widmanstätten lines while the texture is very coarse and granular, the grains being bounded by almost definite planes suggesting crystals.

Practical Applications of Temperature Measurement

Selecting the Proper Type of Thermometer for Different Uses

By Robert S. Whipple

PRACTICAL CONSIDERATIONS.

The successful employment of thermometers for the measurement of either high or low temperature depends upon the selection of the type of thermometer and on the method of using them. It is frequently difficult to advise definitely any one type of instrument, as questions of first cost, up-keep, etc., all have to be considered.

The following suggestions may, perhaps, be of assistance to those considering the installation of such instruments.

Steam Plant.—As a rule the temperatures throughout a steam plant may be taken with mercury thermometers, sockets or mercury cups being placed in the steam-pipes into which the mercury thermometers are placed. On the other hand, it is frequently troublesome to read the important thermometers in the plant, and they often go unread. The thermometer at the foot of the smoke stack, and the one on each side of the economizer, although giving valuable information as to the efficiency of the plant, are frequently unnoticed. For this reason it is advisable to install resistance thermometers, which can be readily read on a galvanometer mounted in the boiler or engine-house. When dealing with high superheat temperatures, a recorder or an alarm thermometer will be found of service.

Cold Storage.—Mercury thermometers are generally employed for this work, but experience has shown that in the case of large stores—say ten rooms or over—it pays to install resistance thermometers. A great deal of time is spent in reading mercury thermometers throughout a large building which necessitates the opening and shutting of a number of doors, and which, in addition to the labor cost, is wasteful of power and tends to destroy the uniformity of temperature in the various rooms.

The Treatment of Metals.—The applications of pyrometers in works for the treatment of metal are very varied.

Hot-Air Main.—One of the most important is the measurement of the temperature of the air in the hot-air main of a blast-furnace. If prime cost is not an overwhelming consideration, then resistance thermometers should be used connected to a Callendar Recorder. The record reproduced, Fig. 26, was obtained with such an instrument. Thermo-couples may be used, but if an accuracy comparable to that of the resistance thermometer is desired, then the Scale Control Board, and the various precautions with regard to the cold junctions, etc., outlined in a previous article (see SCIENTIFIC AMERICAN SUPPLEMENT, page 298), must be adopted.

Casting Temperatures.—Unfortunately, although the temperature at which a metal is cast is admitted to be of such great importance, yet there is no really satisfactory way of determining the temperature of the molten metal. The conditions, especially where a large crucible is used, make it practically impossible to insert a pyrometer into the metal, and the readings obtained with radiation or optical pyrometers are not consistent, owing to variations in the quality and quantity of the slag and the frequently great divergence from black-body conditions.

The closed-tube radiation pyrometer can be safely used when small crucibles are employed; the thermocouple also, if protected by an outer salamander tube, may be used for taking temperatures of molten brass.

Annealing and Hardening.—The greatest field for the application of pyrometers lies in the heat treatment of metals, and here the success of a pyrometer installation depends almost entirely on the way in which the pyrometer is mounted in the furnace. The author has dealt very fully in a previous paper with this aspect of the matter.[14] Experience shows that, in the case of large furnaces, it is advisable to put the thermometer in the floor of the furnace in the way suggested by Mr. F. Culpan. A slot *S*, Fig. 27, is chipped into the furnace floor and into this a fire-clay tube *T* is grouted, the space surrounding the tube being filled in with fire-clay flush with the bottom of the furnace. The pyrometer *P* is

[14]"The Application of Pyrometers to Hardening and Annealing," R. S. Whipple, Proc. Birmingham Association of Mechanical Engineers, March, 1913.

slipped into the tube *T* through the side of the furnace. The weight of the head of the pyrometer is taken by a flanged socket, which is screwed into the protective plating of the furnace, the pyrometer being held to the socket by means of readily removable bolts and nuts. The plan of the arrangement is shown, and from this it will be seen that the pyrometer can be introduced between the gas ports of the furnace. For various other methods for mounting pyrometers both horizontally and vertically reference must be made to the paper mentioned.

The record reproduced in Fig. 28, obtained by means of a thermo-couple placed in an annealing furnace and connected to a thread recorder, will show how admirably with a little practice a fireman is able to maintain a given temperature over many hours. In this case the management had ruled a line on the record sheet, and had instructed him to maintain the temperature constant for a definite number of hours.

The determination of the critical and freezing-points of metals and their alloys is of vital importance in metallurgical work, but the subject is too large to be dealt with in a Paper of this kind; but special reference may be made to Papers by Dr. Burgess[15] and Dr. Rosenhain.[16]

Brick and Porcelain Works.—In practically all porcelain works Seger cones are employed to control the firing. Although the information given by them is extremely valuable as showing the maximum temperature attained, yet they fail to show the rate at which a kiln is being heated, and this is frequently of fundamental importance. Thermo-couples are best employed for the measurement of the lower or preliminary temperatures and radiation pyrometers for the higher or finishing temperatures. The author has previously discussed the mounting and use of these pyrometers when applied to the measurement of the temperature of pottery kilns.[17]

Experimental Work.—It is impossible to mention all the modern applications of thermometers as applied to Engineering. The experimental work of Professors Callendar and Nicholson[18] on the temperature cycle in the steam-engine cylinder, and those by Professors Burstall,[19] Hopkinson,[20] Dr. Dugald Clerk,[21] and the Reports of the British Association Committee on Gaseous Explosions, are well known to all members of the Institution.

It is not necessary to refer members of the Institution to the pyrometric work carried out by Dr. Rosenhain and his colleagues at the National Physical Laboratory, acting on behalf of the Alloys Research Committee. Reference to the Reports of this Committee shows how dependent the metals are upon the temperatures to which they have been subjected.

In determining the efficiency of the winding of dynamo field coils, thermo-couples built into the machines have given valuable information.[22]

Some work has been carried out recently by Professor Barnes with a view to detecting thermometrically the presents of icebergs. It is found that if the thermometer is sufficiently sensitive, the temperature gradients in the water, owing to the slow melting of the ice, can be detected at distances as great as five miles. Professor Barnes has designed a resistance thermometer, used in conjunction with a Callendar Recorder fitted with a special relay, which is able to detect and record changes in the temperature of the water of 0.001 deg. Cent. It is hoped that it may be possible to equip a vessel with apparatus of this kind which will sound an automatic alarm when the ship is approaching a berg. A good deal of experimental work has still to be done, however, before this stage can be said to have been reached.[23]

Standardization of Thermometers.—The question of standardization is of great importance to all users of thermometers, whether they are employed to measure high or low temperatures. Unless immediately pressed for time, an observer will find it advisable to send his instruments to the National Physical Laboratory where it will be examined and its corrections determined for an extremely moderate fee. In a works where there are a large number of instruments, it is advisable to keep a set of instruments which have been examined at the National Physical Laboratory as standards of reference. If this is not possible, corrections at one or two points in the range of the thermometer can generally be determined. In the case of mercury thermometers the freezing (0 deg. Cent.) and boiling (100 deg. Cent.) points of water must be observed—care being taken to correct for variations in the height of the barometer when taking the latter point.

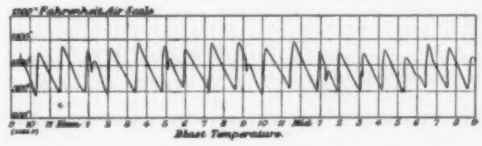


Fig. 26.—Temperature of a blast-furnace main, obtained on a Callendar recorder. (Scale one third original.)

The boiling points of:—

Aniline	184.1 deg. Cent.
Naphthalene	218.0 deg. Cent.
Benzophenone . . .	306.0 deg. Cent.

may all be used for standardization points. Aniline oxidizes readily, and naphthalene will be found satisfactory. It is cheap and readily obtained of sufficient purity. This is best tested by taking its freezing-point, which should be 80.0 deg. Cent. A special, but simple, boiling-point apparatus must be used with both naphthalene and benzophenone.

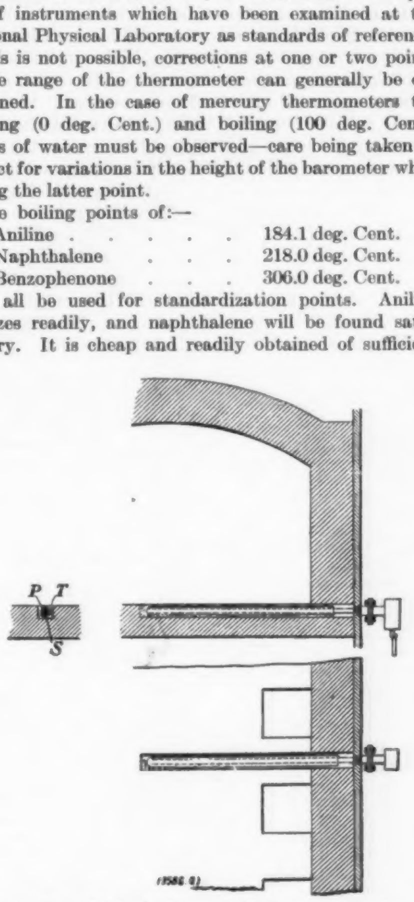


Fig. 27.—Method of mounting a pyrometer. (Culpan.)

For higher temperatures it is advisable to use the melting-points of pure metals or eutectic alloys and the freezing-points of pure salts.

The following will be found useful and satisfactory points:—

Freezing-point of Tin.	231.92 deg. Cent.
Freezing-point of Lead.	327.43 deg. Cent.
Freezing-point of Zinc[24].	419.37 deg. Cent.
Boiling-point of Sulphur.	444.70 deg. Cent.
Freezing-point of Antimony.	630.7 deg. Cent.
Freezing-point of Sodium Chloride . .	800 deg. Cent.
Freezing-point of Silver.	960.98 deg. Cent.
Freezing-point of Copper.	1083.0 deg. Cent.

In the case of radiation and optical pyrometers, the best way is to sight upon a piece of firebrick or porcelain placed in either a small tube electric furnace or gas-fired muffle. A standardized thermo-electric couple is mounted either on the face of the firebrick or through a hole in its center, the pyrometer being focussed on the couple. The furnace is then heated and the readings of the pyrometer compared at various temperatures. If a thermo-couple is not available, a single melting-point will be a valuable check on the pyrometer. A triangle is cut out of a piece of thin sheet silver, and one side partly folded over so that the sample will stand up when placed in the furnace. The pyrometer is then focussed on the tip of the triangle, and the point when it melts (960.88 deg. Cent.) observed.

When standardizing radiation and optical pyrometers, care must be taken to ensure that the conditions satisfy black-body requirements.

[15] "On Methods of Obtaining Cooling Curves," G. K. Burgess, *Bulletin Bureau of Standards*, vol. 5, page 199. 1908.

[16] "Observation on Recalescence Curves," W. Rosenhain, *Phys. Soc.*, Lond. vol. 21, page 180. 1908.

[17] "Pyrometry as Applied to the Making of Pottery," R. S. Whipple. Transactions of the English Ceramic Society, January, 1913.

[18] "On the Law of Condensation of Steam deduced from Measurements of Temperature—Cycles of the Walls and Steam in the Cylinder of a steam Engine," H. L. Callendar and J. T. Nicholson. *Proceedings* Inst. C. E., page 131. 1898.

[19] "The Measurement of Cyclically Varying Temperatures," H. F. W. Burstall.—*Phil. Mag.*, vol. 40, page 282. 1895.

[20] "Gas Engine Temperatures," Hopkinson.—*Phil. Mag.*, vol. 13, page 84. 1907.

[21] "The Present Position of Gas and Petrol Engines," Dugald Clerk.—*The Electrician*, 9th August, 1907.

[22] "Report on Temperature Experiments carried out at the National Physical Laboratory," E. H. Rayner.—*Journ. Inst. Elect. Eng.*, vol. xxxiv. page 628.

[23] "Report on the Influence of Icebergs and Land on the Temperature of the Sea, as shown by the use of the Micro-Thermometer, etc." H. T. Barnes.—Supplement to the 45th Annual Report of the Department of Marine and Fisheries, 1911-12. Ottawa.

[24] The freezing point of zinc is a particularly useful point, as determinations made on sample continuously for six years in one crucible gave strictly consistent results.

Fig. 28.—Temperature record of an annealing furnace obtained with a thread recorder. (Scale about one fifth original.)

The Rôle of Colors in Nature

By E. K. Hanson, M. A.

Everyone is familiar with some of the numerous examples in which the coloring of the animal harmonizes with his surroundings, so as to allow him to escape notice. The black and yellow stripes of the tiger, so striking at the Zoo, blend completely with the light and shade in jungle-grass, and mask its approach from its prey. The harmonizing of animal coloring with surroundings, for purposes of protection, is found in many caterpillars and insects. Sometimes, again, a weak and harmless creature has the characteristic coloring of some dangerous species, and secures in this way freedom from molestation. Wasps and bees are closely imitated by insects of other orders, a specially close imitation occurring between a Borneo beetle and a compatriot wasp. Similar instances of protective coloring are known in the plant world: for example, the scanty vegetation of desert regions often bears an extraordinarily close resemblance to the ground or rocks on which it grows, whereby it becomes less liable to be devoured by vegetarian animals.

But of late years it has been shown that certain pigments have a much more fundamental part in the life of the world. Chlorophyll, the leaf-pigment, is mainly responsible for the glorious greens of our vegetation. It is not too much to say that through chlorophyll the whole world of plants and animals is kept alive. In the chlorophyll plants alone, so far as we know definitely, are prepared the food-stuffs necessary for all living animals, as for plants. By the aid of sunlight, the chlorophyll manufactures sugars and starch, from which other foods are in turn derived by reactions with nitrates and other salts derived from the earth; to produce the starch, chlorophyll requires only water and carbon dioxide, and it liberates oxygen in the process, thus providing food and fresh air for us in one mysterious transformation! The steps by which the result is achieved were guessed by Liebig, but have been definitely demonstrated only within the last ten years. There is first formed from the water and carbon-dioxide a substance known to chemists as formaldehyde; it was this first step that was longest obscure. From the formaldehyde there is then formed successively sugar and starch: the presence of the last-named being easily demonstrated in green leaves after exposure for a few hours to bright light. Formaldehyde, by the way, is sold in a 60 per cent solution called "formalin," as a disinfectant, and is also used in photography to harden gelatine films.

Sunlight is necessary for the action of chlorophyll; this leads us to another interesting case of color utility. It has long been known that seaweeds vary in color, according to the depth of their habitat below the surface of the water Surface weeds are green, shallow water weeds are yellow or brown, deep water weeds are red or crimson It has been further shown that chlorophyll occurs in all these weeds, though its color is masked by the other more intense pigments What is the function of these last? Attention has been mainly directed to the red weeds, and it has been shown that in all probability the red pigment is an assistant to chlorophyll. For chlorophyll needs not only light, but a special kind of light (red) to do its work of building up starch. Now water is not entirely transparent, and it happens to absorb red light most. Consequently, at great depths, there is little, or no, red light, and chlorophyll alone would be useless. The red pigment has been shown to have the extraordinary property of transforming blue light into red (a case of what is known as fluorescence), and as blue light penetrates water to great depths, these deep-water seaweeds can utilize the light they obtain by the help of the red pigment and the green chlorophyll acting, as it were, successively. Many other examples have been found of the usefulness of color—that the bright colors of flowers serve to attract insects is another very familiar fact—but there is still ample room for fresh investigations on the rôle of colors in Nature.—*The University Correspondent.*

NEW BOOKS, ETC.

WOMAN IN SCIENCE. By H. J. Mozans, A.M., Ph.D. New York and London: D. Appleton & Co., 1913.

While Dr. Mozans has made out a rather good case on behalf of the achievements of women in science, it seems to us that in his enthusiasm he has overshot the mark. In the whole history of science, ancient and modern, there is not a single womanly figure that deserves to be placed side by side with Hipparchus, Archimedes, Tycho, Kepler, Galileo, Newton, Lavoisier, Darwin, or a score of equally brilliant men that might be named. Undoubtedly the most distinguished woman in the whole history of science is Madame Curie, to whom we owe the discovery of radium. Remarkable as her work is, she has contributed very little indeed to the interpretation of radium or the advancement of the modern ideas of matter, more or less inspired by the phenomena of radium. She is one of the most skillful laboratory experimenters, exactly what one would expect of the receptive woman. In a recent paper published in *Science* by Prof. Cattell under the title "Statistical Study of American Men of Science," reference is made to the fact that women are contributing but a very small share to productive scientific work. In 1910 only eighteen women are found among the first thousand scientific authors. Prof. Cattell says: "There are now nearly as many women as men who receive a college degree; they have, on the average, more leisure. There are four times as many women as men engaged in teaching. There does not appear to be any social prejudice against women engaging in scientific work, and it is difficult to avoid the conclusion that there is an innate sexual disqualification. . . . But it is possible that the lack of encouragement and sympathy is greater than appears on the surface, and that in the future women may be able to do their share for the advancement of science."

Although Dr. Mozans has evidently read much in order to write this interesting book, his arguments in behalf of women consist chiefly of quotations from great writers of the past. This amounts merely to an array of expressions of opinion, and not to evidence of woman's capacity. If one critically examines the achievements of the few women who have made a name for themselves in science, it must be conceded that their most heroic attempts seem small compared with the achievements of the male giants of thought. No woman has ever written a great epic poem; no woman has ever painted a great historical painting; no woman has ever written a great symphony or a great opera; and just as truly it may be said that no woman has as yet achieved a truly commanding place in science beside the very greatest leaders in science. If this is so, the fault is in part due to man. Woman is entirely what man has made her. For centuries she has been either a household servant or an odalisque, as John Stuart Mill once put it. Now that the shackles have been removed, now that she is able to educate herself on an equal footing with man, we may expect more of her.

A HISTORY OF THE UNITED STATES. By Henry E. Bourne and Elbert J. Benton. Boston: D. C. Heath & Co., 1913. Cloth. Maps and illustrations. 598 pp. Price, $1.

This is an excellent history of the United States. It is extremely readable, and can be perused by older persons with great advantage. The maps are particularly to be commended. The illustrations are well chosen, and are executed in line, thus enabling the book to be printed on paper which does not injure the eyes. The book is pre-eminently fitted to prepare pupils now in grammar schools for intelligent entrance upon the duties of citizenship. In the selection of matter, the interesting manner of presentation, and the centers of interest developed, the book deserves all praise. It is noteworthy that the authors have included an adequate treatment of the West, which previous books have generally neglected. The treatment of the South is sympathetic and informing. In accordance with the recommendations of the Committee of Eight, the European background of American history has been kept in mind, and intelligent and helpful use of this appears in appropriate points in the book. Among the numerous histories for grammar grades that have appeared in recent years, the work of Drs. Bourne and Benton is unique. This judgment applies not only to the form in which it is presented, but also to its merits in rendering service of the right sort to the rising generation.

FIRES AND FIRE-FIGHTERS. A History of Modern Fire-fighting. With a Review of Its Development from Earliest Times. By John Kenlon, Chief of the New York Fire Department. With illustrations from photographs. New York: George H. Doran Company, 1913.

Chief Kenlon has given us in this book an interesting story of personal experiences, but what is more, a critical account of modern construction and insurance methods. He compares our American methods with the methods of Europe, not always to our advantage. Chief Kenlon seems to feel that the newspaper criticisms of the great fire insurance companies are more than justified. He finds it nothing short of shocking that fire risks of considerable value should be accepted without the searching inquiries which are inevitable in Europe. It is amazing to learn from his pages that in New York the loss by arson annually amounts to four million dollars alone. Indeed, Chief Kenlon even goes so far as to hint that "fire-making" is a recognized vocation. "During the spring, fires in the fur trades are prevalent, while hat and cap fires usually occur in the summer. From September to December it is peculiar that the ready-made cloak and suit trade suffers severely, while any change of fashion in millinery and feathers is invariably followed by a corresponding destruction of old stock, through fire. The advent of the motor car heralded the burning out of hundreds of stables, and now the influx of cheap automobiles into the market appears to approach to overproduction, since garage outbreaks have become virtually incessant."

FARM GAS ENGINES. By C. F. Hirshfeld, M.M.E., and T. C. Ulbricht, M.M.E. Small. 239 pp.; 8vo.; 188 figures. New York and London: Wiley & Sons, 1913. Price, $1.50.

The enormous increase in the use of agricultural engines is a sufficient excuse for a text-book on the gasoline engine as applied to the farm. That Prof. Hirshfeld and Mr. Ulbricht would respond to the demand for such a book adequately would follow from their prominent positions on the teaching staff of Sibley College of Cornell University. The authors necessarily discuss the principle of internal combustion engines, very much in the same way as it is discussed in other text-books on internal combustion motors. They seem to have kept in mind the fact that they were writing for a class of men who, while intelligent and familiar with at least the elements of mechanics, had no very intimate knowledge of gasoline engines and their construction. After carefully studying this book, the farmer will be able to decide which type of tractor or stationary engine will best meet his needs.

ARE THE PLANETS INHABITED? By E. Walter Maunder, M.R.A.S., London and New York: Harper & Bros., 1913.

In this instructive little book Mr. Maunder takes up the planets one by one and presents the evidence for and against their being inhabited. As might be supposed, Mars plays the predominant part in his discussion, and Prof. Lowell's views are sharply attacked. While we are by no means committed to Lowell's views, it seems to us that this question can never be settled until a committee of the foremost telescopic observers in the world proceed to Flagstaff and study Mars in the wonderfully clear atmosphere of Arizona. Lowell insists that he can see more with his 26-inch glass than is possible with a very much more powerful instrument in a hazy latitude. He has to be sure, the more difficult side to defend, and it is easy for knowing critics like Maunder to oppose his assertions with an array of evidence which seems really overwhelming.

THE MAJOR OPERATIONS OF THE NAVIES, WAR OF AMERICAN INDEPENDENCE. By A. T. Mahan. Boston: Little, Brown & Co., 1913.

This book, as the author assures us in his preface, comprises the subject matter of a chapter which was contributed under the title of "Major Operations, 1762 to 1783" to the "History of the Royal Navy." As might be expected in so thoughtful a student of naval affairs, Admiral Mahan drives home the importance of the naval conflicts of the American Revolution so that they teach a modern lesson. In his admirable introduction he brings out how far-reaching are the effects of ill-advised measures. Who would have thought that when protests were raised against the Stamp Act and the measures that succeeded it, the East and West Indies, the English Channel and Gibraltar would vibrate in response? "The surrender of Burgoyne determined the intervention of France, in 1778; the intervention of France, the accession of Spain thereto in 1779." And so he proceeds to trace the influence of a foolish parlimentary act down even to the affairs of India and the Cape of Good Hope when it was still a Dutch possession. Admiral Mahan describes in detail the various naval engagements which took place during the war, illustrating his narrative with diagrams of the positions assumed by the conflicting ships.

ENCYCLOPÆDIA OF ETIQUETTE. A Book of Manners for Everyday Use. By Emily Holt. Garden City, New York: Doubleday, Page & Co., 1912. 8vo.; 498 pp.; illustrated. Price, $1 net.

That this work has entered its forty-first thousand speaks eloquently for its popularity. The present revised and enlarged edition gives us a volume sufficiently exhaustive to merit the title of encyclopedia. The phrase of its sub-title, however, holds even more praiseworthy truth, for it is indeed a book of manners for everyday use, and not a collection of ridiculous punctilios such as are too many of its kind. A feature of the new edition, and one that will appeal to many, is the inclusion of new chapters on foreign countries. It is safe to consult this authority on what to do, what to say, what to write, and what to wear, with certainty that her advice will never push ceremony to the verge of the ludicrous or the edge of the impossible, for in any choice between rules of conduct, the more simple, natural, and direct mode is given the right of way.

A JOURNEY TO THE EARTH'S INTERIOR. Or Have the Poles Really Been Discovered? By Marshall B. Gardner. Aurora, Ill.: Published by the Author, 1913.

The mammoth and the mastodon still live, and the races immediately beneath our feet are not Mongolian or Negro, but unknown denizens of an undiscovered world; to wit, the interior of the earth. Such is the contention of Mr. Gardner of Aurora, Ill., and the sheer ingenuity of his arguments makes the little book worthy of the Jules Vernean reader. Our earth is conceived of as a hollow shell with an habitable interior, the line of gravity running through the heart of the crust, and polar openings some 1,400 miles in diameter giving access to the interior. The position of the line of gravity explains the dipping of the compass when our explorers reach a point at the edge of the opening. The interior of the earth is heated and illuminated by a central sun whose rays, emerging at the poles through cloud strata, give us our aurora borealis. The freshness of the mastodon steaks eaten at a certain St. Petersburg banquet is accounted for by assuming that the animal, far from being an ancient relic, was a recent wanderer from the earth's interior. This conception of the hollowness of our mundane life is not new, but we do not remember having before seen it worked out with such a wealth of detail.

ALTERNATING CURRENTS AND ALTERNATING CURRENT MACHINERY. By Dugald C. Jackson, C.E., and John Price Jackson, M.E., Sc.D. New York: The Macmillan Company, 1913. 8vo.; 968 pp.; illustrated. Price, $5.50.

This work has be-n widely and favorably known since its first publication in 1896. It now appears in an enlarged form, and rewritten to keep pace with modern developments. Much new material is presented in respect to vectors, complex quantities, and Fourier's series, which will prove useful to the student and the engineer. There is a fuller treatment of power and power factor; of the self-inductance and mutual inductance of line circuits and skin effect in electric conductors; and of synchronous machines and asynchronous motors and generators. The text constitutes a full course in the elements of alternating currents and their practical applications, and is so arranged that shorter courses may be taught from it by omitting certain chapters. Either as text-book or as reference book the volume has a high value.

THE MAGNATE OR THE PEOPLE. Or Lowest Instead of Highest Railroad Rates in the World. By Martin Johnson. Milwaukee, Wis.: C. N. Casper Company, 1913.

Here we have a scathing arraignment of American railroad management, and an intense statement of the argument for nationalization. The work is marred by a regrettable extravagance and redundancy of style, the more regrettable because when the author calms down to figures and deductions he has something very definite and significant to give us. There are illuminating glimpses into the realms of "frenzied finance," and our managers' comparisons of American and European railroad service to the detriment of the European are shown to be very largely perversions of fact. The work maintains that we are paying the highest freight and passenger rates in the world; that our "fliers" aside from those on a very few much-talked-of runs are a joke, when compared with the express service of France and Great Britain; and that in the safe, cheap and expeditious transportation of passengers and freight our managers are but tyros when compared with European systematizers. The thoughtful man might with profit read this work, guarding himself against being carried away by its flood of hyperbole, and then turn to the opposite statement of the question as found in "The Railway Age." Somewhere between these two extremes lies the truth, and only by approximating to that may we solve our railway problem or any other problem.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION. Showing the Operations, Expenditures, and Condition of the Institution for the Year Ending June 30th, 1912. Washington: Government Printing Office, 1913. 8vo.; 780 pp.; illustrated.

The explorations and researches carried on during 1912 under the auspices of the institution were both interesting and fruitful, as is evidenced in the summaries presented in the report. It is the general appendix, however, that appeals most to the ordinary reader, for here he finds keen and thoughtful papers on the latest developments of modern science, penned by the world's leaders in thought and research. Astronomy, the constitution of matter, the latest achievements in chemistry, applied mechanics, geophysical studies, entomology, the nature and origin of life, these titles give some idea of the remarkable range of subjects. The list of writers includes such names as Poincaré, Sir William Ramsay, and Amundsen. Poincaré's lecture on the connection between the ether and matter is a masterly epitome of the theories and discussions of the Société française de Physique, in which all modern theories are examined, and their strengths and weaknesses alike disclosed. Prof. Schafer's contribution on the nature, origin, and maintenance of life is also a crystallization of modern knowledge and speculation, and is supplemented by Armstrong's "The Origin of Life." But all the papers show rich fields worked with gratifying results.

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